DISCOVERY

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Edited by Bernard Lintern.

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Notes of the Month

Does life exist on other planets? Factors which are said to preclude this possibility are set out by Dr. W. S. Adams of Washington, who has just completed spectroscopic investigations of the planets in the solar system. In the case of Mercury, he finds that the planet is too hot and too small to hold an atmosphere. Venus has neither oxygen nor water above the dense clouds which hide its surface, but it does have carbon dioxide, which shows that plants, if any, are not numerous. The possibility of life is least remote in the case of this planet, but without plant life there can be no animals or human beings. Mars, is so small, and its gravity so weak, that its atmosphere is thin. It has polar caps suggesting water, but the spectrum shows no free oxygen. The outer planets have temperatures far below zero: their great masses enable them to hold dense atmospheres, containing gases which are rare in the earth's atmosphere: the poisonous gas ammonia is a fairly abundant constituent of their atmospheres, but oxygen has not been found in any of them. Commenting on these conclusions, *Nature* suggests that imaginative enthusiasts who project interplanetary journeys in rockets must envisage a complete departure from the solar system, and conduct an extensive search among the satellites—if any—of some of the nearer stars, if they wish to find a landing place at which they can avoid suffocation at the end of their journey.

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Two branches of science which always make a popular appeal were much "in the news" last month. Archæological finds were made at several sites at home and abroad—at St. Albans, at Ur of the Chaldees, in Constantinople and elsewhere; and plans for several Polar expeditions were announced. Excavation of the prehistoric and Roman cities at Verulamium (St. Albans) has been conducted since 1930 by Dr. and Mrs. Mortimer Wheeler, who have just given an account of the latest discoveries to the Society of Antiquaries. In pre-Roman times Verulamium was a royal capital and the most important city in Britain. Its importance continued into Roman times and it was awarded the highest status a provincial city could receive. Authentic records show that even in the "dark age" which followed, Verulamium clearly maintained its position. Before the excavations were instituted nothing was known of the city during these three phases in its history. Now, Dr. Wheeler states, something about all of them has been revealed. The pre-Roman city of King Tasciovanus was replaced by a new town after the Roman invasion, and this in turn was superseded by an extensive Roman city in the second century. The excavation of buildings and streets within the fortifications of this city was continued during the summer and autumn of last year. The foundations of a triumphal arch (the only one of its kind known in Britain), the remains of a second century temple of triangular design and a Roman theatre (originally discovered in 1847 but subsequently reburied) are among the most impressive finds. Dr. Wheeler will contribute a full account of last season's work to *Discovery* next month.

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Meanwhile at Ur of the Chaldees in Mesopotamia excavations have been resumed for the thirteenth year. Mr. Leonard Woolley, the director, reports the discovery of a female statue in the grave of a soldier, which is unusual since no statue has ever

before been found at Ur which had any connexion with a burial place. Mr. Woolley does not explain the significance of this position, which would be interesting. The latest instance of "accidental discovery" is reported from Constantinople where workmen engaged in drainage operations near St. Sofia have unearthed a wall believed to be the "axis" of the Byzantine hippodrome which has for long eluded archæologists. It will be interesting to learn whether this identification by the Turkish museum authorities is confirmed.

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Plans are being completed for two British Polar expeditions, one to the Arctic under the leadership of Lieutenant Martin Lindsay, and the other to the Antarctic to be led by Mr. J. R. Rymill. Both leaders are young but tried explorers and the progress of their expeditions will be watched with interest. Lindsay's party, which is leaving shortly for Greenland, is to explore the last important stretch of territory still unknown in the Far North. Plans are outlined in *The Times*, which states that the expedition will endeavour to explore the unknown stretch of mountainous country half way up the east coast of Greenland, which is believed to contain one or more ranges higher than any yet chartered within the Arctic Circle. The journey will involve a thousand miles of sledging, which will be the longest journey made without food depots along the route in country where there is no game. The question whether the Antarctic is one continent or two may at last be solved by Rymill's expedition, which leaves England for Graham Land in September. Its object is to explore a thousand miles of unknown coastline in the portion of the Antarctic known as the Falkland Island Dependency. The expedition will be away for nearly three years and its cost is estimated at £15,000.

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We are glad to announce that Dr. Cyril Bailey has been nominated by the British Academy to be a Trustee of *Discovery* in succession to the late Professor Conway. Dr. Bailey is classical tutor at Balliol College, Oxford, and Public Orator of the University. By the death of Professor Conway *Discovery* lost the guidance and advice of an eminent classicist whose place it was difficult to fill. There could be no more appropriate successor than Dr. Bailey, and we may confidently look forward to the advantage of his co-operation on the classical side, where we are already fortunate in having the advice of Sir Frederic Kenyon. Dr. Bailey has many other interests; he is concerned in a practical way with education, being a member of the council of Marlborough, and a governor of King's School, Worcester; and he is an enthusiastic mountaineer. In a mechanical age insufficient importance is attached to the classics in education and Dr. Bailey appropriately drew attention to their neglect at a recent prize-giving. He rightly urged the value to-day of a study of the classics since it taught the student to understand the characteristics of different nations, and that knowledge was essential for world peace.

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The election of Sir James Jeans as President of the British Association this year will be widely welcomed both in scientific circles and by the many members of the general public who attend the annual meetings. Sir William Hardy had already been elected for this year when his death unexpectedly occurred. Sir James Jeans has probably done more than any other specialist in modern times to make the intricacies of mathematical physics intelligible and interesting to the layman and many of his books have been best sellers. The Presidential address to the British Association commands greater public attention than any other exposition from the world of science, and Sir James Jeans' address at Aberdeen next September will be awaited with more than ordinary interest.

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Everyone with a shred of feeling for birds will support the Archbishop of Canterbury's appeal to the Government to take in hand at once the scandal of oil-discharge by ships at sea. The suffering and death caused to birds by this means is lamentable, and international agreement is long overdue. As Dr. Lang pointed out at the annual meeting of the Royal Society for the Protection of Birds, the cost of oil separators is less than it used to be, and some of the prominent shipping companies are willing to introduce them. The Government is reported to be "in correspondence with the recalcitrant nations"; and we can only hope that more haste will be shown than is sometimes the case where the promotion of international agreement is concerned. A correspondent to *The Times* urges British shipowners to take the lead without delay; and everyone will agree that decisive action on the part of Great Britain will be more effective than waiting for the uncertain chance of international agreement through discussions at Geneva. The Society for the Protection of Birds deserves every credit for its part in securing the passing of the Protection of Birds Act last year, and it may be relied upon to pursue the question of oil discharge with the same vigour. It remains for the shipping companies to co-operate in an effort to remedy an evil which can only be contemplated with indignation.

Science To-day and To-morrow.

The layman may well be baffled by the increasing complexities of scientific research as technique becomes more and more specialized. To mark our anniversary we publish below a symposium in which the latest progress in eight sciences is simply but lucidly stated. It forms a unique record of more than momentary interest.

Anthropology.

By Lord Raglan.

ANTHROPOLOGY may be divided into three main branches. The first, human biology, may be sub-divided into general and racial biology. General biology deals with the origin and development of the human species as a whole and its connexion with, or resemblance to, other living creatures; racial biology deals with the various races into which the human species is divided, their origin, distribution and reaction to their physical environment.

Lord Raglan.

The second branch is technology, which studies man through the works of his hands. It again may be sub-divided into two branches, early technology or prehistoric archæology, which traces the development of tools and other artefacts from the earliest stone age up to historic times, and modern technology, which deals with recent artefacts especially those of savages. Such subjects as Egyptology on the one hand and mechanics on the other are usually excluded from anthropology, not because they are without interest for anthropologists but because they are so vast as to require specialization. The third branch is social anthropology, which studies man through his institutions, customs, beliefs and mental processes.

The great object of anthropology is to explain why man, both savage and civilized, is what he is and does what he does. In human biology the most important of recent events have been the discoveries of early human remains by Dr. Black in China, Miss Garrod and others in Palestine, and Dr. Leakey in East Africa. The result of these discoveries has been to confirm the view, already held generally but not universally, that all the existing races of mankind are descended from a common stock, and to suggest that this stock in something like its modern form has been in existence for very much longer than was previously supposed.

At one time skin colour and hair texture were regarded as the chief criteria of race. These were largely superseded by the cephalic index and a tendency to divide the human species into long-heads and round-heads. Nobody has yet explained satisfactorily how people come to have black skin or round heads, but there is now a tendency to attribute it to the action of the endocrine glands. The distribution of blood-groups is being studied in the hope that it may afford a clue to racial origins.

In technology the discoveries of Dr. Woolley at Ur, Miss Caton-Thompson and others in Egypt, and Sir John Marshall on the Indus, continue to push the beginnings of civilization further and further back, while careful comparison of the sequence and technique of artefacts from all over the world is making it more difficult to hold the old fashioned theory that these artefacts were invented independently.

Social anthropology is now in the melting pot. The great work of the older school, which culminated in Sir James Frazer's monumental work *The Golden Bough*, was to show the essential similarity underlying all the customs and beliefs of mankind. This was, however, attributed to nature; it was supposed that it all came either from our animal ancestors or from the natural working of the human mind. It is now beginning to be realized that nothing in animal life affords any precedent for human custom; that the human mind does not work except in response to external stimuli; and that the simplest beliefs of the simplest people are really echoes of ancient civilizations.

The next step in anthropology is to correlate theories of human origins with these facts.

Archæology.

By Professor John L. Myres, F.B.A., F.S.A.

So many excavations now occur every season that it is only practicable to illustrate, by a selected few, principal objectives and advances of archæological technique. For archæology, like any other study, has its strategy and its tactics which become rationalized and precise as experience is won. The days of happy-go-lucky adventure—"I have a little money; let's go and dig somewhere"—are indeed not over. For fantastic hunting after "Solomon's mines" or the "tomb of Alexander" there is usually wealth and to spare; while whole periods and cultures are being laboriously reconstructed from surface-finds or travellers' "trial-pits." Official supervisions of monuments and sites, now recognized as a public service by many governments, should result—and sometimes does—in forethought and choice of really significant sites, large or small; for it is not the area but the depth of an excavation that usually makes it memorable; not the splendour of the monuments, nor even the wealth of documents, but the geographical location—the fact that men needed to live there at all, and the way they managed to do so.

The following additions to knowledge are in approximate order of the periods which they illustrate.

Among recent journeys into Eastern Libya, the Almasy-Penderel expedition has been conspicuous for its clearly defined geographical objective, and consequently for the significance of its archæological finds; especially the proof of progressive and recent desertion of a district formerly fertile, and the rock paintings and associated implement-types from Jebel Uweinat, important links between those of Eastern Spain and of South Africa. An advance in method here was the combination of air-reconnaissance and air transport with the surface exploration.

The Greatest of Eastern Empires.

Persepolis has long been known as a great site, but Herzfeld's excavation of its palace has exceeded all hopes, in amount and excellence of its architecture and relief-carving, and wealth of Achæmenid documents. We may now learn at first hand how the greatest of Eastern Empires was governed, and the art of Persepolis prepares us to appreciate the ideas of Darius. A remarkable feature, here as at Knossos, is the preservation of great edifices to within a foot or two of surface soil, once the superstructure has been devastated.

In Crete, an Iron Age cemetery near Knossos has rock-tombs so ingeniously packed with successive urn-burials, that it is possible to recognize the order in which each was deposited and consequently its relative age; an unusually sure and delicate standard of artistic and industrial progress from Late Minoan decline to renaissance under Oriental influence, in an obscure period for which Crete may well come to be a primary source of information.

Early Greek Architecture.

At Perachora on the promontory that splits the east end of the Corinthian Gulf, a small sanctuary, probably the guardian of a beacon, like a mediæval lighthouse chapel, yields dedications in pottery, bronze, and ivory, continuously stratified from the last Bronze Age into classical times. In the foundations of a mediæval chapel, which has been removed, were found the most interesting objects of all, clay models of a primitive Greek temple, with portico at one end, semi-circular apse at the other, as in Middle Bronze Age dwellings, and thatched roof with twisted rope-binding along the ridge. The significance of this glimpse of early Greek architecture is obvious.

In the Agora of Athens, American excavation confirms the great depth of accumulated rubbish—10,000 tons on one and a half acres—over buildings such as the Royal Portico, headquarters of the King Archon, and the Altar of the Great Gods, memorable in Herodotus' tale (vi, 108) of the Platæan alliance. Both are the more welcome, as landmarks in Pausanias' description of the city. The smaller finds include really fine sculpture of several periods, ballot-discs to illustrate Athenian ingenuity in secret-voting, and actual *ostraca* from the voting of 483 B.C. when "Aristides the Just" was banished: one of them even bears his name. Though nothing surprising or exceptionally fine has been found this year, this great enterprise—by far the largest excavation in Greece hitherto—is an epoch-making in its way as the clearance of the Imperial Fora in Rome.

Here the slum-quarter between the Forum Romanum and the Piazza Venezia has been transformed into a park belt and avenue. Trajan's Column no longer protrudes from a noisome den of stray cats, but dominates ruinous but still palatial colonnades and halls. The remains of the Forum of Augustus begin to stand free. Most impressive of all, the Capitol, dwarfed though it unfortunately is by the modern National Monument, reveals itself as a citadel indeed, detached and defensible. Seldom have public utility and archæological discovery been so happily combined. At Ostia, convenience is less urgent, but the excavated town compares even with Pompeii in instructiveness.

Astronomy.

By Professor Herbert Dingle, D.Sc.

THE past year has not been marked by any conspicuous advance in astronomy. It has been rather one of those years—ultimately of at least equal importance with the great landmarks—in which accumulation of data in all branches of the subject has continued unimpeded by the impact of disturbing speculations. The immediate effect of such a period, in a study so enormous and many-sided as astronomy, is inevitably to increase perplexity. The evidence of different researches appears contradictory when viewed from the standpoint of existing ideas, and only in the future can its value be properly assessed. When, to the temporary confusion thus caused, is added that aroused by the recent revolutionary discoveries in physics—which call for a re-formulation of our notions of the physical constitution of stars, nebulæ, and intergalactic space—it will be understood that the present is no time for a report on progress.

Professor Dingle.

To select any particular department of study for special notice would be to give a false emphasis, unless it is clearly recognized that the selection is solely for purposes of exemplification. With this understanding we may mention first a group of researches on the structure of the galactic system, which includes studies of absorption of light in space, the rotation of the galaxy, and the existence and character of the "local cluster" of stars. There appears to be considerable evidence that light is absorbed in space, but determinations by different methods of the amount of the effect are inconsistent with one another, thus casting uncertainty over the many conclusions which are drawn from the accepted values of the absolute magnitudes of stars.

Among such conclusions are estimates of the extent of the galactic system, the distance of the sun from the centre of the system and, in fact, large distances generally. In this connexion improved photo-electric methods of measuring luminosity have made valuable contributions to knowledge, but their evidence is at present indecisive. The analysis of the velocities of stars, from which the phenomenon known as the "rotation of the galaxy" was deduced, still presents ambiguities. Considerable discussion is going on concerning the scope of the phenomenon, the view that it is characteristic of a local cluster of stars forming only a small part of the whole galactic system being maintained in some quarters. The evidence for the existence of such a cluster is strong, but if the galaxy as a whole is rotating as it appears to be, the survival of this partially independent system, in spite of the disintegrating influences of rotation, presents an unsolved dynamical problem.

As a second example of the transitional stage through which we are passing may be mentioned that topic of general interest—the nature of the universe. An apparently new method of approaching the theoretical problem, which was advanced by Milne, has been shown to be a special case of the general relativity treatment, and although there remain some important differences between it and the more generally accepted "expanding universe" idea, no prospect of a decisive observation presents itself. In the meantime, however, Hubble has consolidated our knowledge, such as it is, of the density of distribution of matter in space, which he finds to be uniform out to the farthest distances yet accessible, with a minimum value of about 10^{-30} gms. per cc. He remarks, however, that unobservable intergalactic matter might exist in sufficient quantity to increase this figure a thousandfold.

It is clear that the immediate task of astronomy is to investigate, not to dogmatize.

Biology.

By Professor Charles Singer, D.Litt., M.D.

WHAT are the most striking features of that minute fraction of the material world which we call "living"?

(1) Its variety becomes daily more impressive. About $1\frac{1}{4}$ million species are known. Many thousands are added yearly. Comparable additions will long continue. The nature of these contributions is, however, monotonous. Most are in the insect group. Many new genera are annually revealed but

probably very few of the comprehensive living groups, such as *Orders*, remain undiscovered.

(2) Biological exploration is revealing few new types but numerous and striking variants on known types. Organic nature is prodigal of variety; niggard of invention.

(3) Since the world is far less explored geologically than geographically, a large increase in our knowledge of the number of fossil forms may be predicted. Experience suggests that nearly all will belong to extinct lines and of these some few will suggest, but not provide, the ancestors of living types. True ancestral types will be extremely rare.

Professor Singer.

(4) The discovery and definition of species yields no general formulæ, even vaguely quantitative, for the nature of species. Until this fundamental conception can be given measureable value, biological science must demand different methods and different mental equipment from physical science.

(5) That species have arisen in an evolutionary manner stands firm. The doctrine is peculiar in that it depends not on direct evidence but on the cumulative impression that no other explanation of the phenomena is at all credible.

(6) Turning from species to the packets of living matter called organisms, we are overwhelmed by figures of astronomic order. A putrifying drop contains more living things than the globe contains human beings. Are these animalcules separately existing individuals in the same sense as we? Answers are sought both in the organisms themselves, in their modes of reproduction, and in their relations to their environment (especially their living environment). In the end we may come to regard the essential biological unit as a combination or relation of organism and environment.

(7) Work on the mechanism of living organisms has yielded few generalizations applicable to all. Physiology has concentrated mostly on "higher" forms in which separate systems, assimilatory, excretory, etc., serve separate functions. Comparative physiology, which considers these functions throughout the living series, is still in its infancy.

(8) Despite theoretical consideration of the organism as a *mechanism* to be analytically considered, there is a growing tendency, especially in the study of behaviour, to treat the organism as a "whole" which is greater than the sum of its parts.

(9) There is rapid increase in knowledge of the chemical processes associated with various forms of vital activity (Biochemistry). Here, too, there has been concentration on "higher" forms. Operations carried on with elaborate apparatus in the laboratory and in the separate systems of the higher forms may, however, criss-cross within the apparently undifferentiated substance of a microscopic cell. Physiology of the cell and especially of the "lower" and "unicellular" organisms is the biochemical crux.

(10) In increasing degree the phenomena of inheritance have been shown to be particulate. There are, moreover, occasional jumps or "mutations" of character which are now susceptible of experimental production. Intelligible theories of particulate inheritance and of mutation are now available which link the sexual process with the character of the offspring.

(11) Some biochemical interpretation of the phenomena of inheritance and mutation is the great advance which perhaps may be expected of the next generation.

Exploration.

By Brig.-Gen. Sir Percy Sykes, K.C.I.E.

MANY wonderful events have recently happened and are still happening in the present generation, so much so that they are but dimly realized as they crowd in upon us. This is certainly the case as regards exploration.

The last great unknown area outside the polar regions was the Ruba'-al-Khali, the vast "Empty Quarter" of Southern Arabia, and thanks to two great British explorers, Bertram Thomas and Philby, the curtain which concealed its sinister secrets has been rent in pieces. Some years before Bertram Thomas started on his great adventure, I was invited to join a committee whose object was to raise funds for a distinguished airman to fly across the great waste. Not only did I refuse, but I pointed out that such a

flight would have little scientific value, while it would assuredly lessen the honour due to explorers who were preparing to penetrate its fastnesses.

Consequently I rejoiced when Bertram Thomas completed his epoch-making journey from the Arabian Sea to the Persian Gulf. To quote Lawrence, " Few men are able to close an epoch. We cannot know the first man who walked the inviolate earth for newness sake : but Bertram Thomas is the last : he did his journey in the antique way, by pain of his camel's legs."

Among the most potent aids is the wonderful discovery of flight, and to Binney belongs the honour of first utilizing a seaplane for survey and photography in connexion with the exploration of North-East Land in 1924. After being nearly drowned, the leader of the Oxford University Arctic Expedition was able to make considerable use of flight. In 1925, Amundsen attempted to reach the North Pole with two flying-boats but failed, whereas Byrd in 1926 flew from Spitsbergen to the North Pole and back, to be followed two days later by Amundsen, Nobile and Ellsworth who, in the Italian semi-rigid airship *Norge*, flew from Spitsbergen to Point Barrow in Alaska. They reached the Pole in sixteen hours and arrived safely in Alaska some thirty hours later. Ever ambitious to outstrip his rivals, Wilkins in 1928 flew from Alaska to Spitsbergen, a distance of 1,200 miles, in twenty hours.

Sir Percy Sykes. [*Russell*

To turn to the Antarctic, Wilkins was the pioneer of flying and discovered that Graham's Land, instead of being a peninsula, was really a group of islands. Byrd arrived on the scene later and in 1929 flew to the South Pole and back in nineteen hours. At the time of writing Byrd, who is again exploring in the Antarctic, has reported that as the result of a recent flight, he has proved that there is no land in the Pacific quadrant of the Antarctic Ocean.

What is perhaps the greatest feat of exploration by aeroplane fell to the British Houston-Everest expedition in 1933. Complete success was won by Lord Clydesdale and his comrades, and in spite of a very dangerous eddy downward they not only flew over but circled round Mount Everest at a height of some 30,000 feet in a wind blowing at an estimated pace of one hundred miles an hour, while a thick plume composed of ice particles added to their difficulties. From this record of complete success we now turn to one of heroic failure, in the third attempt to scale Mount Everest. No modern expedition has been more carefully organized or more fully provided with every sort of equipment, including oxygen. The personnel consisted of the leading British climbers and included men qualified by long experience to lead and inspire the splendid mountaineers, who constituted such an important section of the party. The quest will not be abandoned, but the death of the Dalai Lama may adversely affect the situation, as also the belief that the recent earthquakes in Nepal were caused by the anger of the mountain gods at their sanctuary being invaded by aeroplanes.

To turn to Africa, the combination of motor-lorries and aeroplanes has enabled recent explorers to follow in the footsteps of Hassanein Bey and, during the Almasy-Penderel Expedition of 1933, Dr. Bergmann discovered a large number of most important cave-paintings which may connect up with the cave-paintings of Spain.

Apart from land exploration, we now have the exploration of the upper atmosphere, with the important balloon ascents of Piccard and the unfortunate Russian expedition, while heights up to twenty-three miles are, we learn, reached by smaller balloons bearing registering instruments.

As to explorers, the situation is bright. The valuable schools of exploration at Oxford and Cambridge are now being supplemented by the Public Schools Exploration Society under Surgeon-Commander G. Murray Levick, which annually undertakes an expedition conducted under true exploring conditions.

The Oxford University Expedition 1934-5, under the leadership of the younger Shackleton, will explore Ellesmere Land, with an important range of mountains as a chief objective. The University of Oxford and the Royal Geographical Society are supporting this important expedition, but considerable funds are needed by the leader and organizer before it can start.

Of even greater importance is an Antarctic expedition which has the financial backing and support of H.M.

Government and of the Royal Geographical Society. Under the leadership of Rymill, a member of the Watkins' Arctic Air Route Expedition, the explorers will leave England in September for Graham Land. From this centre the unknown coastline between Luitpold and Charcot Land, a distance of perhaps 1,000 miles, will be explored. This survey of the coastal lands bordering the Weddell Sea will help materially to prove whether or no the Antarctic consists of one or two continents. It is interesting to recall that at one time the same doubt existed about Australia. And we cannot conclude without a reference to a British party under the leadership of Lieut. Martin Lindsay, which is shortly leaving England for Greenland with the object of exploring the last important stretch of territory still unknown in the Far North.

To conclude, in most portions of the globe explorers under the new order have the valuable aids of aeroplane and motor-lorry which, as has been sketched above, have already enabled them to accomplish great deeds. Personally, I feel it a subject for satisfaction that the world was first painfully explored by pioneers in the antique fashion under conditions which produced heroic deeds which illuminate the pages of history down the ages. But " the old order changeth, yielding place to new."

Geology and Plant Life.

By Professor A. C. Seward, Sc.D., F.R.S.

THE request for a short article on the latest progress and the " next step " in that branch of science which makes a strong appeal to some botanists and geologists necessitates selection from many possible subjects. An obvious choice is an illustration of recent progress towards a possible solution of one of the many problems connected with evolution. Search among the records of the rocks has added considerably to our knowledge of the geological history of many groups of plants.

Several years ago Darwin referred to the " abominable mystery " surrounding the origin of flowering plants. The problem is this : the most successful plants in the world, the most numerous, and in the average landscape the most conspicuous, are those which produce reproductive structures commonly called flowers, and bear seeds enclosed in a case—the ovary or fruit—in contrast to firs and other conifers in which the seeds are exposed. Flowering plants are described in text-books as relatively modern and as latter-day products of evolution. This statement is based on the fact that it is not until we reach the Cretaceous period, a stage in the history of the world separated from the present by say one hundred million years, that we find remains of leaves, stems and other organs obviously belonging to broad-leaved flowering trees of a kind with which we are familiar in the vegetation of the present day.

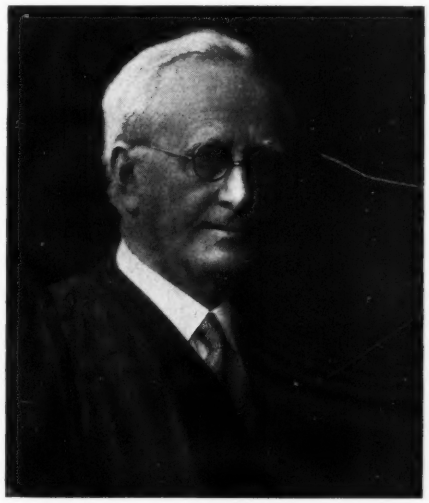
Our ideas of what constitutes a flowering plant are derived from knowledge of living examples, and with one or two exceptions the oldest specimens showing features conforming to those characteristic of existing members of the dominant class are from the deltas and estuaries of Cretaceous rivers. It is, however, certain that the flowering plants as we know them are the descendants of ancestors that have long been extinct, differing in foliage and in their reproductive apparatus from any that are still alive. One of the most striking features of a flowering plant is the enclosure of the seeds in a case or ovary : until recently the study of fossils afforded no indication of the occurrence in rocks older than the Cretaceous period of fruits containing seeds. Seeds are common enough in rocks many million years older than the Cretaceous period ; but they were not enclosed in a fruit.

In 1925 Dr. Hamshaw Thomas of Cambridge gave an account of some fossils, discovered by him in sediments of Jurassic Age on the Yorkshire coast, which may be compared with small currants and are fruits containing seeds in a closed, or almost completely closed, case. He found also small organs bearing bunches of pollen-sacs with pollen in close association with leaves unlike the foliage of any known flowering plant. These leaves, fruits and pollen-sacs, which he referred on good evidence to a single parent-plant, are now included in a special group, the Caytoniales, so called from the locality where much of the material was found. Botanists are by no means agreed as to the relationship of these extinct forms to modern flowering plants, though it is generally admitted that Dr. Thomas's discovery is an important contribution towards a better understanding of the course of development of the most characteristic attribute of flowering plants. A few years ago Dr. Harris of Cambridge discovered in Triassic rocks of East Greenland additional examples of leaves and reproductive organs of the Caytoniales, which agree with the naked-seeded plants in their pollination, though in the general construction of their fruits and other organs they are almost identical with the geologically more recent members of the English Caytoniales.

Recent research has demonstrated the occurrence of plants closely resembling in foliage and in the possession of seed-containing fruits those first recorded from the Yorkshire coast, in many parts of Europe and in the southern hemisphere. These plants may not

have been the direct ancestors of modern flowering plants; they may be members of an entirely extinct offshoot of an unknown and more remote ancestral stock from which the highly specialized and dominant flowering plants were derived.

The question is, can we trace the Caytoniales still farther back, beyond the lower limit of the Triassic period? It has long been known that in the forests of the Coal Age (Carboniferous period) there were many plants with large fern-like leaves and superficially closely resembling ferns, which, however, differed essentially from true ferns in having seeds and not merely spores. Some of the seeds were partially enclosed in an envelope as are those of the hazelnut, but none have so far been discovered within a fruit. These fern-like seed-bearing plants, known as Pteridosperms, were formerly believed to have died out at about the end of the Palæozoic era, and there was no evidence of any connexion with the flowering plants of a much later age. It has now been shown that the Pteridosperms continued to play a conspicuous part in the vegetation of the Triassic and Jurassic periods. A suspicion that some of the common fern-like fossils preserved in the older Mesozoic sediments were the foliage of seed-bearing plants has been confirmed. The intensive study of Triassic fossil plants from Natal and from East Greenland by the botanists already named has furnished evidence, which some of us regard as favourable to the view that the Caytoniales and the still older Pteridosperms are links in a chain ultimately connected with the flowering plants.



Professor Seward.

After a relatively sterile period of many years without any definite contribution to this particular problem, we seem to be within reach of a better understanding of "the ghostly language of the ancient earth." The next step is to search for data which may enable us to follow with greater certainty the history of flowering plants through the ages preceding the Cretaceous period. Progress towards a clearer conception of the gradual evolution of the plant-world is the result not merely of the discovery of fresh material among the samples of vegetation scattered through the rocks, but it is in part due to the employment of an improved technique in the examination of imperfectly preserved and often fragmentary fossils.

Medicine.

By Professor T. R. Elliott, M.D., F.R.S.

MEDICINE moves like the knight on the chessboard, and it is not easy to foretell in which direction the next practical advantage will be secured. Most of the recent gains have been in territories that not long ago seemed inaccessible, while the obvious things still remain the most remote from medical control.

A better grasp of the anæmias has been one happy gain of the last few years. The commonest form of all, chlorosis in young women, vanished during the war, not by any deliberate medical effort but automatically through the social changes which gave these working women a healthier environment. Pernicious anæmia was never common but always fatal. Now it is curable, but no sane physiologist would have ventured to suggest what clinical workers have found to be the intricate story of that malady. The birth place of blood cells is in the marrow of long bones. There they grow, like pupæ in a bee-hive comb, but cannot of themselves come to the last stage of maturity that fits them for escape to the main blood stream. The ripening touch comes from an extrinsic substance, formed by stomach juice acting on meat foods, stored in the liver, and thence supplied at the marrow's need. When the stomach fails in this essential task, the patient grows blanched and feeble. An injection under the skin of an extract from the liver even once a fortnight, will abolish every trace of illness.

Following on this came fresh hope for dealing with all anæmias, and then in the last year or two the absurdly simple observation that many of the common forms can be relieved by trebling the customary dose of iron by the mouth. This change of dosage must have had an immense influence on the aggregate of lives enfeebled by anæmia and it should rank as a discovery, though empirical. The steady formation of blood is therefore seen to require a full supply of

iron and an extremely small supply of an organic chemical substance elaborated elsewhere in the body.

The example of these two factors in the anæmias has some resemblance to what has recently been discovered about certain rarer diseases. Death from failure of the adrenal glands can now be averted by injection of an extract of the cortex of these glands. Where the substance elaborated by the cortex acts in the body to maintain life is unknown, but there are hints that the conservation of a normal level of sodium in the body fluids is at the heart of the question. It has also been discovered that an extract of still smaller glands, the parathyroids, can maintain life otherwise threatened by their failure; and it is now clear that these glands maintain the calcium level of the body fluids, partly by drawing on calcium storehouses in the bones, and thereby keep the nervous system at its normal poise of excitability. These are striking discoveries of intricate devices for maintaining that steady environment in respect of calcium, sodium, and perhaps iron which the living cells of the body seem to need and which is hard to secure for animals that have left the sea and its circumambient supply of these elements.

Most astonishing of all is the knowledge that has been won in respect of the pituitary gland, a tiny mass no larger than a small bean, and sunk in an almost inaccessible position at the very base of the brain. Its activities seem to control those of all the other special glands and also of the processes of reproduction. An exaggeration of its power has been associated with strange changes that may slowly transform Miranda to a Caliban, bearded and hairy, purple-faced, grossly ensheathed with fat that aches, and with a high blood pressure. Æsop with his fable of the members of the body gave but a dim foreshadowing of the delicate balance of glandular secretions which recent research has thus shown to be needed for normality of our bodily frames.

What is Pain?

Clinical research and physiology together have unravelled these intricate mysteries even as a few years ago they solved the equally profound problem of diabetes, showing that so apparently simple an affair as the use of sugar by the tissues, after straightforward digestion and absorption, fails unless the tissues receive together with the sugar a special substance, insulin, elaborated by cells of the same digestive gland which made the sugar from the carbohydrates of the food. Yet the problems which crop out on the surface remain unanswered. There has been no advance in knowledge of ailments of the joints, of neuritis, of the common cold. Pain itself is still only a sign of the place of suffering, its essential nature and its pathway to the conscious mind almost unknown. The problems of insanity remain purely those of the mind, and only a glimmering of light begins to be thrown on chemical processes within the brain.

Most of the advances named above have come from workers in America and Canada. England has given bountifully in the past to practical medicine by her discovery of the vitamins in foods and that work still goes forward. The most recent development offers a novel view of dental decay. Teeth go carious or loose in the gums not so much because they are negligently brushed or the mouth too often filled with sweets, but because they already bear within themselves the fissures and weaknesses which give lodgment to the seeds of decay. They are ill-formed growths in unhealthy gums, and both these tissues are at fault, not primarily from bacterial infection but because the food given to the growing child has lacked the necessary vitamins. This work points the way to preventive means that might result in a great diminution of dental decay and artificial dentures among our younger population. And it should not be forgotten that these researches deliberately aimed at checking decay were for the greater part made through financial support provided by the dental profession of Great Britain.

Physics.

By James Chadwick, D.Sc.

A FEW years ago the main line of advance in physical knowledge was on the theoretical side rather than the experimental. The rapid development of the quantum mechanics and its strangely beautiful completion by the wave theory overshadowed the experimental advances, many of which were complements or predictions of the theory. But recently a change has taken place. Not only did progress on the theoretical side become more difficult but several experimental discoveries were made which caused a transfer of interest. Among these discoveries are those concerning the heavy isotope of hydrogen, the neutron, the transmutation of elements by protons, the positive electron, and the new type of radioactivity. In this brief survey I shall mention only the experiments on transmutation and on the positive electron. I choose these partly for the reason that they show a striking

In the space available it has been possible to deal with each subject only in relatively brief outline. Readers may therefore be glad to have the bibliography on page 97 which will enable them to explore some of the subjects more fully.

feature of modern physics—the close interaction of theory and experiment.

The application of quantum mechanics to the problem of the penetration of potential barriers by particles suggested that protons of moderate energy should be able occasionally to enter the nuclei of the lighter elements. This led to the development of methods of accelerating protons in electric fields and to the discovery of the transmutation of elements by bombardment with protons. The probability of transmutation by a proton even of high energy is extremely small, but very intense beams of protons can be obtained and consequently the effects to be observed are quite large. The transmutation process is, in general, the capture of the proton by the nucleus and the emission of one or more alpha particles. The heavy isotope of hydrogen has also been used as a bombarding particle and seems to be peculiarly effective in promoting transmutation.

The Positive Electron.

The positive electron was discovered in the study of the cosmic radiation. It was then found that positive electrons appear when gamma rays of high energy are absorbed in matter. They can thus be produced in the laboratory and their properties examined. From such experiments it appears that a quantum of sufficient energy may occasionally interact with an atom in such a way that the quantum is absorbed and a pair of electrons, one negative and one positive, is born. The positive electron cannot exist for more than a short time in matter of ordinary density. It soon meets a negative electron and both particles disappear, with the emission of their energy in the form of radiation.

The existence of particles with exactly the properties of these positive electrons was predicted by Dirac's relativistic equation for the motion of an electron in a potential field. This equation gave solutions which seemed to correspond to no observed facts, but which nevertheless were essential to the theory. The experimental discovery of the positive electron provided a very striking support for the theory.

But the positive electron also appears in a way which was not predicted by any theory. In some cases of nuclear transmutations an unstable nucleus is formed which can exist for a time but then transforms into a stable nucleus with the emission of a positive electron. We have here a new type of radioactivity, possibly akin to the beta transformations of the known radioactive bodies; for neither of these types of transformation have we any satisfactory explanation.

Science To-day and To-morrow.

Books to read.

ANTHROPOLOGY.

Essays on the Evolution of Man. By G. Elliot Smith (Oxford University Press).
In Search of Our Ancestors. By G. Elliot Smith (Watts).
The Races of Man. By A. C. Haddon (Cambridge University Press).
Guides to the Horniman Museum. By H. S. Harrison.
Affinities of Man, Monkeys and Apes. By S. Zuckermann (Kegan Paul).
The Progress of Man. By A. M. Hocart (Methuen).

ARCHÆOLOGY.

New Light on the Most Ancient East. By V. Gordon Childe. (Kegan Paul).
Riddles of the Gobi Desert. By Sven Hedin. (Routledge).
The Tomb of Tutankhamen. By Howard Carter. (Cassell).
Egyptian Antiquities of the Nile Valley. By James Baikie. (Methuen).
Tell Halaf. By Max von Oppenheim. (Putnam).
On Ancient Central Asian Tracks. By Sir Aurel Stein. (Macmillan).

ASTRONOMY.

The Expanding Universe. By Sir Arthur Eddington (Cambridge University Press).
The Universe Around Us. Third Edition. By Sir James Jeans (Cambridge University Press).
The Composition of the Stars. By H. N. Russell (Halley Lecture, 1933).
Suns and Worlds. By W. H. Stevenson (New Ch. Press).

BIOLOGY.

Living Organisms, their Origin and Evolution. By E. S. Goodrich (Oxford University Press).
The Philosophical Basis of Biology. By J. S. Haldane (Oxford University Press).
Animal Biology. By J. B. S. Haldane and Julian Huxley (Oxford University Press).
The Nature of Living Matter. By L. Hogben (Sidgwick & Jackson).
A Short History of Biology. By Charles Singer (Oxford University Press).
The Science of Life. By H. G. Wells, Julian Huxley and G. P. Wells (Cassell).

EXPLORATION.

Arabia Felix. By Bertram Thomas (Cape).
The Empty Quarter. By H. St. J Philby (Constable).
The Lost Oases. By Hassanein Bey (Thornton Butterworth).
Exploring the Upper Atmosphere By Dorothy Fisk. (Faber & Faber).

GEOLOGY AND PLANT LIFE.

Extinct Plants and Problems of Evolution. By D. H. Scott (Cambridge University Press).
Plant Life Through the Ages. By A. C. Seward (Cambridge University Press).

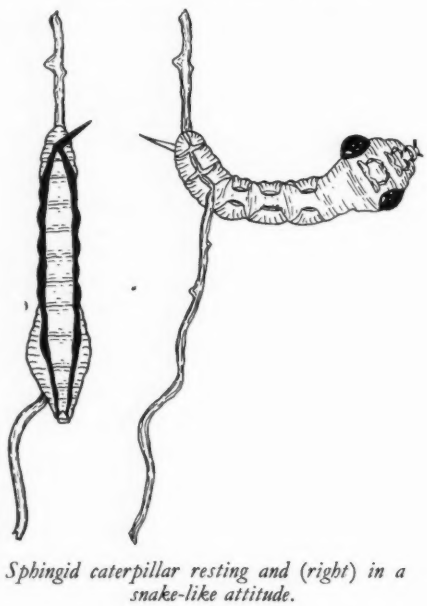
Caterpillars that Mimic Snakes.

By Major R. W. G. Hingston.

Last April the author discussed the meaning of eye-spots in insects and showed how they are used to intimidate an enemy. He now deals with a closely related subject of equal interest. This will be followed by an article by Dr. F. A. Dixey, the distinguished entomologist, who will extend the subject to embrace other fields.

CATERPILLARS appear to be defenceless. They have no facility for swift escape and seldom have powerfully aggressive weapons. Yet they are in special need of defensive machinery, for they are not clothed like full-grown insects in chitinous armour; on the contrary their bodies are soft, tightly-filled tubes which rupture at the slightest peck or stab. What then can they do? They can obviously adopt, what is so common among weak animals, practices of simulation and deceit. Their deceptions are many. Some insects, especially Geometrids, bear the closest resemblance to leaves and stems; others have small humps which match excrescences on bark; some are the image of moss or lichen.

These, however, are strictly concealing devices. More interesting perhaps are the aggressive measures which these weakly-armed creatures adopt towards their enemies. Those with hairs and spines are best equipped in this respect. Often the hair or spine has a poison gland at its base which converts it into a highly efficient weapon. But even in the absence of poison such structures are protective. Birds and lizards dislike hairs and spines in their mouths. Hence a bristly coat is an effective discouragement. Sometimes the hairs and spines are elaborately developed and exhibited in an ostentatious manner whenever an enemy appears. This is well illustrated in Lasiocampids. Just behind the back of the head there is a pair of transverse slits. Inside each slit is a hairy brush which in normal times is hidden from view. When the enemy approaches an astonishing transformation takes place. The slits open and the two brushes are shot out in the form of a pair of velvety manes. The brushes are always conspicuous; in one species they are black, another orange, in another pink, in another steel blue. The colour adds to the aggressive appearance which is sufficient to intimidate a lizard or bird.

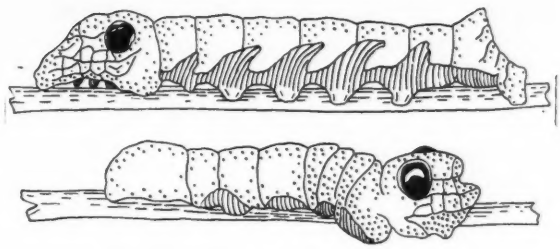


Sphingid caterpillar resting and (right) in a snake-like attitude.

But the most remarkable of all aggressive devices is the plan of mimicking a snake. Those who have not seen this example of nature's counterfeits sometimes doubt its existence, but those who have observed it are perfectly satisfied that a mimicry of the serpent is clearly involved. Examples are to be met with in all parts of the world, but as is the case with every form of mimicry, the device is most elaborately developed in the tropics.

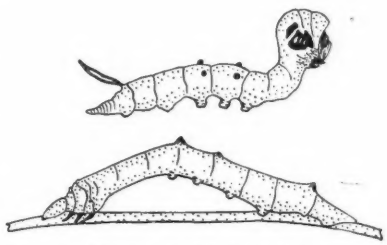
H. W. Bates, when exploring the Amazon, was the first to record the phenomenon. Since then several other examples have been noted. The best that has come under my own observation was the caterpillar of a large Sphingid, probably belonging to the genus *Leucorhampha*, which I met with in the Guiana forest. It was a fleshy greenish-coloured larva marked with two dark stripes along its back. Ordinarily it rested lengthwise along the stem of a creeper, the green leaves of which provided it with suitable concealment. But when I approached it and shook the leaves the caterpillar immediately assumed its snake-like attitude. It reared its body from the stem and stretched out almost horizontally. At the same time it gave a twist so as to present its under surface, simultaneously expanding the front segment of its body into a bulbous oval-shaped enlargement. This expanding of the front end opened a pair of folds that were completely hidden in the resting attitude and revealed on each side of the expansion a large and menacing eye-spot. The eye-spots were black in colour, marked with a few white spots and encircled in a yellow ring which gave the impression of eyelids. For some seconds the creature remained thus poised. Then it allowed itself to sink back slowly to the perpendicular, relaxed its false head, closed its sham eyes and resumed the resting state.

Nobody, seeing this example, could have failed to be struck by the resemblance to a snake. It was an astonishing, an almost staggering counterfeit. The natives who were with me had never before seen it, and they were both amazed and alarmed at the trickery. The snake thus mimicked was the tree-viper, a poisonous species not uncommon in the forest which lives, like the caterpillar, among green leaves. There can be no doubt that the snake-like attitude is protective. It would certainly intimidate a bird.



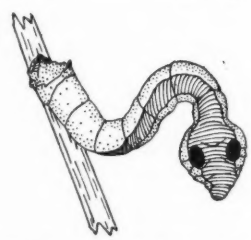
Centroctena resting and (below) as a snake.

But we need not go to the tropics to find "serpent-caterpillars." There is one quite impressive example in England. The full-grown caterpillar of the large elephant hawk moth, *Choerocampa elpenor*, is brown in colour and lives among dead leaves. In such a situation it is well concealed, its bare and withered integument blending well with the brownish background. Most of its body segments are without special markings, but on the first and second abdominal rings there is on each side an eye-spot, in no way conspicuous when the caterpillar is at rest. But touch the leaves and a sudden change occurs. The caterpillar draws back its pointed head, causes the front body-rings that bear the legs to close in tight on one another, and retracts the whole of the eye-spotted segment something after the manner of a folding telescope. The result is that the previously pointed head-end of the caterpillar now becomes a dilated bulb. On the widest part of the bulb appear the eye-spots which have lost their inconspicuous appearance of innocency and now appear to be of enormous size. What the caterpillar has done is to make its head end serpent-like, and it has done so with no small success.



Mimicry in Madory plato.

Another species of the same genus, *Choerocampa mydon*, has been examined by Shelford in Borneo. He compares its counterfeit in detail with the snake *Dendrophis pictus*. The lower edge of its eye-spot is margined with bright gold which lends an upward glance to the eye. The black is so intense and glossy that it gives an impression of depth, and it is difficult to believe that one is not looking through a real cornea into a real pupil. As in the eye of the snake, there is a broad black stripe running through the eye-spot of the caterpillar, while a wrinkled fold on each side gives an exact impression of the division between the upper and lower jaws of the snake. Further, the upper surface of the caterpillar's sham head is reticulated with fine brown lines which lend a realistic impression of the scales on the head of the snake. It is not astonishing that all these details should be woven into the caterpillar's counterfeit?



Leucorhampha mimicking a snake.

"Serpent-caterpillars" abound in Brazil. Perhaps the best example is *Leucorhampha triptolemus*, which has been described and beautifully painted by the Rev. Miles Moss. He aptly compares it with an Aaron's rod, and regards it as one of the most remarkable living creatures that he has ever seen. It hangs vertically from the stem of its food-plant, where it harmonizes with the dull creamy lichen. When disturbed, however, it turns over and exhibits its ventral surface to the enemy. At the same time it expands its front extremity into a bulb. Then a pair of black eye-spots, hitherto concealed, open out on either side of the bulb, with the result that the protectively coloured caterpillar assumes the appearance of the head and neck of a snake. Moreover, the curve adopted by the caterpillar is just like that which the serpent assumes; and as if to make the counterfeit quite perfect, the creature affects a swaying side-to-side movement which it maintains for some seconds. Then, if the cause of the disturbance be removed, it relaxes the bulb, closes the false eyes, and sinks back again into protective concealment against the dull creamy lichen. Mr. Moss may indeed speak of these creatures as "true marvels of creative evolution." A black-and-white sketch cannot do justice to them. One must see in life the sudden apparition, with its glaring

eyes and menacing aspect in order to appreciate the intimidating effect.

A Stem Becomes a Snake.

Madoryx plato is another Brazilian caterpillar described by Mr. Moss. He holds *Leucorhampha* as champion in these fraudulent demonstrations and *Madoryx* a good second. When at rest it simulates the stem of its food-plant. But when alarmed it becomes erect, bends its head towards its legs, puffs out the front segments of its body and exhibits on each side of the expanded area two fierce blue-black eye-spots which at ordinary times are concealed within the skin. The whole effect is suddenly to convert what seems to be an innocent piece of stem suddenly into an open-mouthed snake with red jaws and ferocious eyes.

But perhaps the most remarkable of all examples is the larva of *Centroctena rutherfordi*, found in East Africa by Dr. Van Someren. Its sham eyes project markedly when in the terrifying attitude. It also has the unusual habit of depressing at the same time its caudal horn and throwing the front part of its body into bends which give it a distinctly snake-like undulation. The serpent-like appearance is still further improved by the fact that the caterpillar thrusts forward its two front legs so as to represent the forked tongue, and by the fact that it has on its head a pattern of sham scales very like the real ones on the head of the serpent. Dr. Van Someren has permitted me to make sketches from his photographs of this caterpillar. They show the bulging eyes, sinuous body and pattern of sham scales. But the mimicry of the tongue could not be introduced as it failed to come out in the original photograph.

It may be asked if there is any evidence to show that these snake-like demonstrations cause alarm to an enemy. Is the notion merely fanciful? There is no doubt that they do cause alarm. I am certain that nobody would have touched my Guiana example unless he was aware of the trickery. Experiments point to a similar conclusion. Professor Weismann records that hens hesitated to seize these caterpillars when they were in the defiant attitude. He watched a gallant cock draw back repeatedly before deciding to strike a blow with his bill. On another occasion he put one in a feeding-trough. A sparrow flew down to steal the food. It began cheerily enough, but when it turned round and saw the demonstrating caterpillar it beat a hasty retreat.

Professor Poulton placed a caterpillar before a green lizard. The caterpillar assumed the snake-like attitude. The lizard at once showed unusual timidity, first advancing and then retreating in fright before gaining courage to snap at the caterpillar. "There can be no doubt," writes Professor Poulton, "that the lizard was intimidated at first and that its alarm was due to the appearance of the caterpillar." Evidence of the same kind comes from Africa. There we find a species, *Choerocampa osiris*, which in colour resembles somewhat that of the puff-adder. Sir Guy Marshall gave one to some full-grown baboons. First a female approached cautiously then withdrew in alarm, clearly intimidated by the large blue eye-marks. Then the baboons became very frightened and ran away. Sir Guy next took a caterpillar in his hand and brought it to a male baboon which was tied up. The animal screamed with terror, indicating clearly that the serpent-like appearance filled him with the same emotion that he would experience if confronted with a real serpent.

Dr. Neave tells of another example which successfully imposes on the African natives. Although they eat other sphingid caterpillars, they will not even handle this species. They are afraid of what they call its "eyes," mistaking the eye-spots for real eyes, which is, of course, the essence of the counterfeit. This sudden assumption of a snake-like appearance, though it must strike us as extraordinary, is in reality only an elaborate development of a principle that exists everywhere in nature. We see that the caterpillar has two contrasting patterns of colour, one which is more evident when it is at rest, the other more evident when it is alarmed.

The Angry Lion.

It is a far cry from the caterpillar to the mammal, but it can be shown that there, too, the same principle operates. The lion is of tawny colour, which normally conceals it against the khaki plains. But there are three areas on its body where the tawny colour is replaced by brownish-black. These are the mane, the tail-tuft, and the back of each ear. When the lion is angered in the face of an enemy or rival it expands its mane, swishes its tail-tuft over its back and rotates its ears so as to direct the back surfaces forward. Thus it exhibits the whole of its conspicuous pattern. When undisturbed it makes the most of its concealing pattern, since the mane is retracted, the tail lowered and the ears so turned as to hide their back surfaces. The lion behaves in exactly the same way as the caterpillar when seated peacefully on leaf or stem. But alarm it, and it makes the most of its conspicuous colours. The principle involved is the same as in the case of the caterpillar.

Science and Religion—VI.

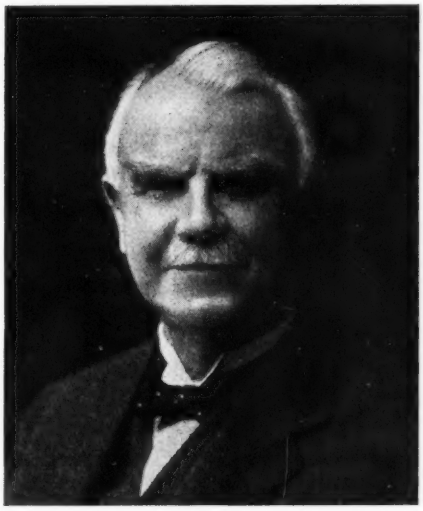
Allied Forces for Progress.

By Sir Alfred Ewing, K.C.B., F.R.S.

In an earlier article Mr. Hilaire Belloc suggested that there is an inevitable conflict between the religious and the scientific spirits. Sir Alfred Ewing describes this vision of two hostile camps as "a mere nightmare." Science and religion, he says, are essentially co-operative factors which must work together for progress.

I HAVE been invited to contribute an article to this series, perhaps because an earlier writer referred to things which I had said in another place.

The title I have chosen is at once a challenge and a confession of faith. It is a challenge to those who insist that between the religious spirit and the scientific spirit there is inevitable conflict which, as Mr. Hilaire Belloc recently assured the readers of *Discovery*, "will act with increasing violence until one or the other conquers, or until the two separate so thoroughly as to dominate separate sections of mankind." To me this vision of two hostile camps with their increasing violence against one another has no basis in present-day realities, and the suggested future with conquest and survival on the part of one, or separated sectional dominance on the part of each, seems a mere nightmare.



Sir Alfred Ewing.

Is there not a trace of unconscious mediævalism behind this judgment? Early traditions tell; no doubt my own view is coloured by the way I was brought up. I was fortunate in having, from boyhood, a foot in either camp—free to follow a bent towards scientific inquiry, and also breathing a spiritual atmosphere which was, I believe, entirely wholesome. Later, too, I was happy in the privilege of working under scientific leaders who found no incompatibility between religion as their rule of life and discovery as their enthralling occupation.

Even in those mid-Victorian days one felt impatient of the emphasis that was laid in some quarters upon quarrels that occasionally arose between exponents of the spiritual and the scientific moods of the mind. Nothing so readily attracts attention from the passer-by as a brawl between people who generally behave with decency and self-restraint. The theologians, as they now themselves admit, were slow to learn the lessons which discovery forced upon them; they tended to cling, unwisely, to positions that should never have been taken up. Some of the spokesmen of science were provocatively cocksure about matters which to-day seem curiously uncertain. In the nineteenth century the ashes were still warm of that intolerance which at an earlier stage in man's development led to the blunders and crimes of the Inquisition. But to say this is only to recognize that civilization does evolve slowly, through phases that are rife with misunderstanding of its own nature and methods and goal. My title is intended to suggest that religion and science are essentially co-operative factors in that process. They are fundamental and enduring faculties which work together to bring about what is called progress. To think of them as antagonists is, in my belief, a grave error. If civilization is to escape disaster it will only be through the guidance and restraint which religion offers. That must permeate the spirit of man if he is to use rightly the enormous powers which science has put into his hands.

Both faculties are primitive. They are characteristics which from the beginning gave man his racial superiority. Much of his history is a record of their influence; they still inspire his actions; they shape his habits and his thoughts. We recognize the significance of primitive religion, but we are apt to think of science as a later product, forgetting that from the first it was no less a distinguishing mark of the human soul. Man is the only tool-making animal; his discovery of fire and its uses, his invention of the wheel and the plough, were masterstrokes revealing the same sort of genius as now gives us the electron and aircraft and wireless. All through man's history and pre-history the spirit of religion and the spirit of science, the aspiration after

goodness and the search for truth, have been the warp and woof of human life. To eradicate either is out of the question ; it would mean nothing less than destruction of the fabric.

The Modern Outlook.

There is no need to linger over the quarrels of the past, nor to excuse them. The church of the Middle Ages was the recognized custodian of matters which it felt to be of tremendous import. It assumed authority in other matters that were outside its province. The scientific spirit challenged that authority and made out a case which the world could not but accept. As time went on the issues changed, but disputes which were in essence not dissimilar continued sporadically, producing an impression of hostility that is slow to disappear. What concerns us now is the altered outlook of the present day—the *entente* which I would venture to ascribe to a growth of Christian humility on both sides, to a greater freedom from dogmatism (also on both sides) and to a conviction, mainly dating from the recent war, that the welfare of mankind urgently demands whatever help religion may be able to provide as a safeguard against the perils which the gifts of science have brought in their train.

As to dogmatism on the part of those who represent religious thought, a layman speaks with diffidence, but it does seem to me that there is less concern now than there was with creeds and formulas and more concern with the direct teaching and example of Jesus. Even a layman may feel that if only His message of brotherly love could govern the relation between man and man, and between nation and nation, most of the problems that now beset us would be solved. The world of to-day is badly in need of the things Christ stands for. As to dogmatism in science, I may repeat a phrase used elsewhere : the only dogma is that there is no dogma. My experience differs from that of Mr. Belloc when he writes that the scientific spirit " produces the specialist who is not to be contradicted." Rather does it produce the specialist who is consciously climbing towards a clearer view-point, who is aware that each advance is tentative, that the aspect it opens up will soon give place to one which will be more comprehensive. For him to become dogmatic would be to confess stoppage, and therefore failure. The recent history of physics tells of surprising revolutions. It brings kaleidoscopic changes and presents logical dilemmas which put dogmatism out of court. The perplexed investigator—even of non-living matter—finds himself in the presence of mystery. He is aware that at best he sees through a glass, darkly—that within the atom there are more things than were dreamt of in his earlier philosophy. And the student of living matter does not so much as begin to understand how it differs from the non-living, nor whence life came, nor how the daily miracle is accomplished through which the movement of matter is affected by the will—much, it would seem, as the course of a train is affected by the pointsman.

So in the world of science we find contacts with the mystic, contacts that make for mutual tolerance, not to say respect. And now the troubles of the time bring a call for closer union. They insistently remind us that the advance of science may, without guidance by the spirit, be a progress to catastrophe. Man's ethical development lags so far behind his growing mastery of natural forces that his own future is jeopardized. We are appalled when we contemplate the ruin that would attend another great war.

For the most part the discoveries and inventions that are perverted to base purposes do in their proper use promote man's welfare. It is not the investigator or the inventor who should be blamed for their actual or potential abuse. Nor can the march of science be checked by the consideration that this or that invention may be misapplied.

It would be a poor world without science. I cannot picture even religion as remaining vital if it were divorced from the pursuit of knowledge. Without the love of truth it might easily drift into superstition and casuistry. It would be a terrible and a short-lived world without religion. Were the ethical sense uprooted from the soil in which it grows it would wither; we should soon become the victims of power applied without conscience or restraint.

The Future of Civilization.

Thus we come back to the starting-point. If man—imperfectly civilized man—is to make real progress, if he is even to hold his place in creation, he must regard religion as an indispensable factor in the civilizing process. Humanity needs both science and religion. Each strengthens the other and is a necessary corrective. As a life-long votary I feel it would be superfluous to dwell on the absorbing interest of science and the value of her gifts. But it is saddening to realize the damage they have done—still more the damage they may do.

There is some soul of goodness in things evil, would men observingly distil it out. That is true, but in these days the world has to face a momentous opposite truth. There is some soul of evil in things good, which needs no distilling. It seethes and presses beneath our feet. We cannot tell where and when it may find vent, nor what, if any, of the things we hold dear will survive the eruption.

Problems of Modern Forestry.

By Ray Bourne.

Imperial Forestry Institute, University of Oxford.

The problems of modern forestry become increasingly complex. An expert here explains how science is helping towards their solution; but he rightly stresses the fact that the awakening of public interest is not the least of the immediate needs.

APART from such examples as the cultivation by the Romans of sweet or Spanish chestnut for the production of vine-stakes, forestry really had its beginnings in the countries of Western Europe, owing to the exhaustion of local supplies of small timber and firewood. The earlier efforts at conservation and control of exploitation were rarely successful. By the thirteenth and fourteenth centuries the shortage was already acute over large tracts. The extension of cultivation at the expense of the forest, the enormous demand for fuel on account of the climate, the general use of timber for constructional purposes, the practice of grazing cattle in forest confines, and the browsing of deer preserved in huge herds for sport, had all combined to reduce to ruin the relics of the primeval forests. The less accessible mountain regions alone remained forest-clad, but even their exploitation had commenced.

By the seventeenth century, the general situation is typified by the use of communal baking-ovens in many towns and villages and by the reports of Colbert's Commissioners, in which the French forests, except for occasional examples of promising pole crops, were described as derelict. In fact, so far as Western Europe is concerned, the very prevalent idea that forests were then more frequent and extensive than they are to-day is entirely erroneous.

Early Work.

In the eighteenth century, reconstruction of the forests still remaining, and extensive afforestation of uneconomic agricultural land, were features of forest practice in many countries. In mountain areas a further stimulus was given to protection and planting by the frequency of avalanches and landslides, or the extent of soil erosion and floods. The principal species cultivated at this time was the oak, on account of its high heating effect as a fuel and its widespread use for constructional purposes, including ship-building. On dry sandy soils, the Scots pine (Scotch fir) was generally preferred to oak, the most notable example being the establishment of extensive pine forests on the Rhine plain in the neighbourhood of Frankfurt and Darmstadt. In hilly regions, the methods devised by foresters to obtain natural regeneration of oak frequently resulted in the increase of the beech at the expense of the oak, and many of the beech forests of the present day date from this time. This only applies in part to this country, because most of the beech woods, even in the Chiltern Hills, are the result of sowings in abandoned arable fields.

Converting Barren Land.

Finally, reference may be made to a classic example of land reclamation by afforestation, in the case of the Landes in south-western France. Erosion along the coast had resulted in the formation of extensive sand dunes, blocking the natural drainage of the country. The successful planting of the swamps and the subsequent fixing of the shifting sand with Maritime pine gradually converted a barren and fever-stricken area into one of the most densely populated and prosperous rural regions of that country.

From the beginning of the nineteenth century, the development of communications and of overseas trade, the increase in the population and its migration to the towns, the discovery of new uses for timber and of substitutes for wood, radically altered the situation. The demand for timber, particularly coniferous or softwood timber, rapidly increased; it was and has since largely been met by exploiting the natural resources of undeveloped tracts of the northern hemisphere, both to the east and west. For instance between 1840 and 1890 this country, which uses less timber per head of the population than almost any other civilized nation, increased its imports sixfold. On the other hand, with the distribution of coal, the demand for firewood gradually declined and the conversion was commenced of large areas of forest from fuel to timber production. In general the importance of broad-leaved or hardwood forests diminished while the value of softwood forests rose, particularly the spruce forests as suppliers of pulp for the manufacture of paper.

The reaction to the changing conditions was most marked in central Europe, where extensive cultivation of spruce was undertaken. Objections to the introduction of this tree into lowland country, on the grounds that it was a mountain or northern species, were countered by the argument that it resulted in increased profits, provided that it was considered mature at a relatively early age. Indeed during the last century central European forestry was ruled by

economic theorists, who stressed the significance of compound interest on capital outlay unproductive for any length of time. Since a sum invested at two, three or four per cent. multiplies respectively seven, nineteen or fifty times in a hundred years, there is no question of the need for cheap money and land for planting, quick returns in the form of thinnings, low running expenses, early maturity and good prices.

Events, however, have confounded the theorists in several respects. For instance, the spruce in pure plantations, away from its native home, has been subject to costly ravages by insect and fungal pests to which it is normally immune. Its effect on the soil has also often been disastrous, the deterioration being such that the yields of many forests have now been reduced by a hundred per cent. or more. Again, the timber has generally proved to be much inferior to that of the mountain or northern spruce, being relatively fast-grown and in consequence spongy, of uneven grain and frequently full of knots. In fact, as a result of these experiences German forest practice, which at one time was upheld as the example to follow, is now in process of reconstruction.

Virgin mountain spruce of high value at 1,350 m. elevation, in the Jura mountains.

The problem of reconstruction, which to-day faces many countries besides Germany, is generally complicated by the poor prices ruling for low-grade material. During the last century, so long as the extension in supplies from natural forests hardly kept pace with the expansion in demand, almost any timber was saleable. By the beginning of the present century, however, there was already an indication of a possible limit to demand. The growth in the use of such substitutes for wood as iron and concrete has in fact been so rapid that apart from the period of the war, the total demands for timber have ceased to increase for some time. Actually, the demand for high-grade timber has continued to rise, but this has been counteracted by a reduction in the use of poor material. With the recent fall in the general level of commodity prices, the revenues of many managed forests, in spite of their relative accessibility, have been enormously affected. For instance in 1932 for the first time in its history, the German forest estate failed to market its yield and to produce a net income.

Other European countries are more or less in the same position and one of the principal reasons is that the quality of their products, with notable exceptions, cannot compare with those of North America, Scandinavia, Finland and Russia. A general rise in commodity prices will at least locally ameliorate the situation in managed forests, but in general it is likely to accelerate the fall in demand for low-grade material. Indeed, the benefits of a general rise in prices will accrue more and more to countries producing high-grade timber, a tendency which will be accentuated as the original virgin supplies from these countries are gradually exhausted. On the other hand prospects of any material rise in prices for low-grade material are remote. In fact, in many cases, it is likely to become unsaleable unless new markets can be found.

Outside Europe, the practice of forestry is in its infancy. In North America the principal task of the forester has been to save from destruction by fire the natural or artificial re-growth on the areas exploited for lumber. How the timber from the re-growth will compare in quality with that from the original stands depends on the local conditions, but in many cases it is and will be required to meet the world's demands for pulp wood and other wood products such as artificial silk. In the tropics, the forest departments have also to some extent been concerned with fire protection but with a view to the preservation of soil cover as well as of the trees. Owing to the high temperatures which prevail and the activities of ants, there is little accumulation of organic matter on the soil surface in the form of turf or mould, with the result that soil erosion is liable to be very rapid, and floods are extensive. Huge tracts have been devastated or rendered barren by the indiscriminate clearing of forest in the past. For instance, the state of affairs which exists in China is largely a reflection of the fact that forest destruction has forced an enormous population into too small a space. And it may be said that

to a lesser degree the same holds true for India. In parts of Africa, with a rapid increase in the population, a similar result is in time to be feared. Though of little commercial value except to the local population, the forests of the drier regions are often of such indirect value to the country as a whole that selected forest areas should be preserved at all costs. There are, of course, forests of greater commercial value in the humid tropics but their extent is relatively small. Locally they have been exploited for the supply of high-grade timbers and some extension of working is indicated. But many of the timbers are unduly heavy and on this account, at least, they are difficult to place on the market in competition with temperate hardwoods. The same applies to many of the hardwoods in the torrid regions of the southern hemisphere. Extensive afforestation with coniferous softwoods is, however, being undertaken in these zones.

Planted silver fur and spruce of relatively low value at 600 m. elevation, Swiss Plateau.

In consideration of the space available, this brief and general review of forest activity must suffice as a background for a statement of the aims and objects of forestry. Clearly it is both a business and a science. As a business it has obligations to fulfil apart from the yielding of profit. As a science one of its principal functions is to ensure the safety of the capital invested, not only in the forests but even in the land in general. The production of revenue, however, must be the first consideration of the forest owner or manager.

One of the most urgent problems, therefore, is the creation of new markets for small timber of indifferent quality. The solution undoubtedly lies in the conversion of wood into other forms such as pulp, artificial silk and power alcohol. If processes can be perfected and cheapened there is enormous scope for the expansion of markets in this direction. Research into these questions should obviously be fostered and extended.

A second problem of no less importance is the production of better quality timber in managed forests. The solution lies in a more scientific study of the local conditions, the determination of the best races or strains of a species to cultivate in a locality, and the creation of crops conducive to the production of even-grained timber of optimum density and free from defects. Until recently foresters largely relied on empirical methods to achieve the desired results and, as already indicated, they have rarely succeeded. Now they are alive to the necessity for a more scientific approach to these problems. Much research, however, is involved, for the execution of which funds and workers with high scientific qualifications are urgently needed.

The responsibility for the solution of these problems obviously lies with forest owners, whether private individuals or the State, but a proper appreciation of what is being done, and support for the rapid extension of the work is long overdue. For instance, the public should be made to realize that the scientific maintenance of profitable woodland or forest in almost any agricultural region would do much to ensure the prosperity of the rural population. The work in the forest can generally be organized in the agricultural off-season, thus increasing permanent employment, while the creation of forest industries may even relieve the congestion in the towns. In many continental districts, the majority of agricultural workers rely on the forests for winter work, with the result that the rural population has been maintained and the production of agricultural crops is relatively cheap.

Again, though this only applies to certain regions and more to the tropics than to temperate climates, the maintenance of forests on selected soils, whether the undertaking is directly profitable or not, may be very necessary for the preservation of water supplies, the prevention of floods and the restriction of erosion. The importance of this aspect of forestry has already been emphasized. The problems of modern forestry are not only more numerous but far more complex than those of the past. Much is being done towards their solution, but much more is required and an awakening of public interest is not the least of the immediate needs.

Television and National Welfare.

By Sir Ambrose Fleming, F.R.S.

Television is among the most interesting of the technical applications of science. How can it contribute to the national welfare?

WIRELESS telegraphy has a valuable application in effecting communication between ships and the shore, and has been the means of saving countless lives. It is now seen, however, that all these mechanical inventions have a double character. They may be in some ways of great utility, but they often create also unemployment for many and may even be made the implements of crime.

It cannot be said that the invention of the petrol motor has been an unmixed blessing. It causes the death of seven thousand persons annually in Great Britain alone. It has created a new manufacturing industry and injured an older one. The same may be said for broadcasting, which centres round the invention of the thermionic valve and radio appliances generally. It has given music to millions of listeners, but it has rendered more difficult the earning of a livelihood by numerous musicians.

At the present time television has hardly had a chance to prove its utility. Controlled as it is, its exhibition is only given at the inconvenient hour of 11 p.m., when few are able to see it. The advances made in the use of short waves and the introduction of cathode-ray tubes have enabled us to transmit images on screens 3 or 4 feet square, visible to large audiences at the receiving stations. We thus have an extremely valuable means of education. Lectures and school lessons can be given by radio speech and illustrated by television diagrams or pictures.

Television Films.

Where more entertainment is desired it will be possible before long to transmit special films of moving objects and thus to bring the cinema into every home. These innovations oblige us to consider how far mechanical invention is responsible for unemployment. Some hold that the replacement of manual skill by mechanical power is a fundamental cause of our present distress. Others think that our methods of production have outrun our power of distribution. Probably a still more basic cause is the enormous waste of world wealth and natural resources in wars and preparation for wars.

Invention requires guidance and control, and it is difficult to introduce new methods and ideas when any one branch of activity has become centralized in a few hands or petrified by becoming a Government monopoly. This makes it necessary to point out how many disadvantages arise from erroneous or premature legislation intended to control invention. This may be illustrated by the history of telegraphy, telephony, electric lighting and wireless telegraphy. When after 1837 electric telegraphy became practicable by numerous inventions, public companies were formed to exploit it. About 1866 opposition began to be raised to the growth of what was called another "monopoly." Acts of Parliament were passed in 1868 and 69 to enable them to buy out the telegraph companies.

Official Obstructions.

These Acts were drawn with such skill that even ten years later when the telephone was invented and exchanges established, telephony was held to be subject to the Acts. Unfortunately this decision rested merely on a judgment given in a Court of first instance and was never confirmed by a higher Court. The General Post Office offered the Telephone Companies a licence for 30 years in exchange for a royalty of 10% on their receipts. During those 30 years it took nearly a million and a half sterling from the telephone, but it blocked the way to advances in the art during all that time.

The same story was repeated with domestic lighting. In 1882 the Government passed an Act ironically termed an Act to "facilitate" it, but in fact it simply "throttled" it for six years until an amending Act was carried in 1886. A similar fate attended wireless telegraphy. In 1904 it was placed under the control of the Postmaster-General. In 1926 when broadcasting had become an important service, a charter committed it to the domination of the B.B.C. and its small group of governors.

Television is now in the grasp of the same power, and it is given no chance to prove its utility at 11 p.m., when few people have any use for it. It is therefore clear that premature legislation can easily cripple a nascent industry and bind it in bandages of red tape. It is beyond defence that an invention which was not dreamed of at the date of a certain Act of Parliament should be controlled by that Act.

In conclusion, I wish to advocate an extension of the period of patent protection which at present is 14 years in Great Britain, unless specially extended. An invention is no use to the public until it becomes practically available or commercialized, and this generally requires time and great expenditure. It is not possible to secure this without some reasonable prospect of return upon the capital, and in most cases a large part of the period of patent protection has elapsed before the point of commercial success is reached.

[This article is based on a lecture to the Television Society of which the author is President.]

Excavating a Roman Theatre.

By Jotham Johnson.

Field Director of Excavations for the University Museum of Philadelphia.

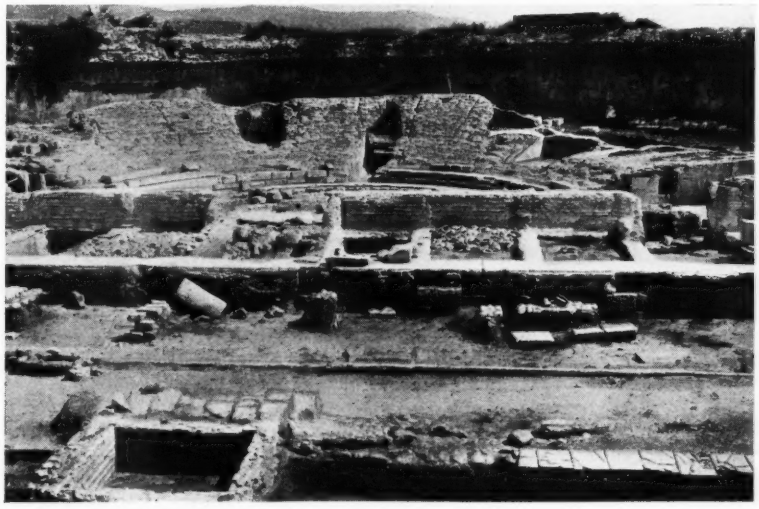
The first season's excavations of the Roman colony at Minturnae were described by Dr. Johnson in DISCOVERY *last April. The second stage of the work was recently brought to a close. An extensive undertaking was the clearing of the stage and orchestra of the theatre, built at the close of Augustus' reign.*

"MINTURNO . . . a most noble city, built by the Ausonian people in the year of Rome 253. There lived 280,000 people, including foreigners, and in addition 4,000 Hebrews. It was divided by twelve principal streets, with a very spacious piazza in the centre. Here stood a famous column of oriental stone, on whose top stood the bronze statue of Tiberius, who magnificently decorated that piazza through which flows the river Liris (to-day the Garigliano) which empties into the nearby Tyrrhenian Sea. This city was known for its thirty-four temples, of which sixteen dated from the days of pagan worship; among these latter were the temples of Thundering Jove, of the Divine Marica, of the Good Goddess, and of Castor and Pollux.

"The Imperial Palace, which in the great days lodged the members of the royal family, faced the Temple of Mars, in the Street of the Siren; at the end of this street rose the great amphitheatre, whose remains are still to be seen on the right bank of the Liris. The great Temple of Jove was flanked by two majestic fountains, which received water from the great aqueduct, which reaches to the roots of the nearby mountains. In the eastern part of the city, in the far end of the palace of the magnificent 'Minturno,' which was situated in the great Street of the Sun, rose the famous pyramid of marble; there stood the statue of Augustus Cæsar, erected by the people of Minturno when that emperor honoured the city with his presence two years before his death.

"The twelve streets which divided the city, all crossing at right angles, and from which issued various minor streets, were thus named: Street of the Sun, which was the most important of all; Street of the Siren, from a fountain which contained a statue of a Siren; Street of Nero, because it was constructed in the first year of Nero's reign; Street of Prosperpina; Street of the Tiger, so called from the day when a tiger, escaping from the amphitheatre, tore three children to bits; Street of Peace, for the Temple of Peace which stood there; Street of Neptune, named after a Temple of Neptune; Street of the Moon, because from the rising to the setting of the Moon it was never deprived of its rays; Street of the Pacelli, for having been rebuilt at the expense of this noble family; Street of Scipio, named either from the great monument to Scipio Africanus or from his brief residence there; Street of Romulus; Street of the Sea, so named because it was the only one which led down to the sea."

This I have translated faithfully from *Minturno e Traetto*, a volume published in 1873 by Francescantonio Riccardelli, a priest of Minturno. Riccardelli more than implies that this passage was composed at the opening of the sixteenth century by an older writer, Draccarielli. According to our priest, Draccarielli had access to certain classical texts which have not survived to our day, but from which Draccarielli culled priceless descriptions of cities to incorporate in his book *De Campania sacra et civile*—Riccardelli, of course,



A view from the south of the theatre at Minturnae, Italy.

quoting the passages which refer to Minturnæ.

It would be pleasant indeed if we, the excavators, could paste this verbal map of Minturnæ on the covers of our field books and proceed to the points of interest thus enumerated. Even the famous Pausanias was seldom at pains so clearly to describe the cities which he visited, and the account is so thorough that in fact it might have seemed more useful to science to select a less known city for excavation.

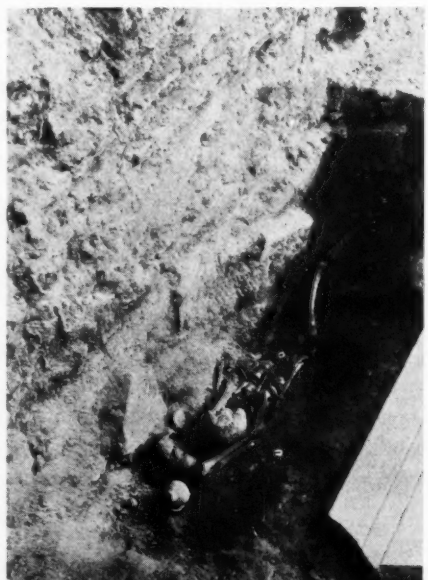
But more sober scholars who wished to read Draccarielli found his book difficult to find. Suspicion grew while Mommsen, editing the *Corpus* of Campanian inscriptions, branded the Minturnese texts reported by Riccardelli as spurious—"*Falsi sunt omnes falsique ita, ut iram risus temperet*"—and sent a friend to interview Riccardelli about his sources. Riccardelli at once joined the increasing company of repudiated patriots whose devotion to their cities had led them down the paths of fiction where facts explained inadequately the greatness of their past. No one now believes in the existence of Draccarielli.

And yet in that part of Minturnæ which we have excavated stands the great Temple of Jove, and on either side of it is a majestic fountain; nearby, in the Forum ("a most spacious piazza") stands a foundation so massive that nothing less than a monumental column would explain it; and a nearby street (Pacelli Street?) was at some moment repaved from one end to the other—a remarkable fact in view of the durability of the Roman basalt paving block. These details lay far underground before our work started; Riccardelli never saw them. Who, then, told him about them?

Excavators who preceded us on the site could have told us a great deal about what they saw had they undertaken to leave coherent records. For instance, we have only the most summary narrative of a visit to the city by a professional patron of the arts at the close of the eighteenth century. This man uncovered a select group of statues and inscriptions, which he loaded on a small boat waiting in the narrow river nearby. He was about to set off to market his finds when a courier from the Bourbon King dashed up with orders to hold the shipment until connoisseurs should arrive from Naples to select appropriate examples for the Royal Museum. When these delegates arrived the statues and inscriptions lay on the bed of the river. Explanations were made with apologies and many expressions of regret; so terrifying a storm had arisen that the safety of the boat and even the lives of its company were imperilled, necessitating the immediate discharge of the cargo.

After some months of residence by the river we formed a bathing party one hot July day at the spot where we guessed the finds to have been dropped overboard. When we had rowed out to midstream and dropped anchor, the voices of the boatmen were raised in disparagement; they observed that the river was twenty-seven feet deep—which we could not believe—and that we could never reach the bottom.

They were quite right. By hauling myself overhand down the anchor rope I failed by three feet to touch even the anchor, and returned, gasping, to the surface. After three successive failures, Paul Beidler, who was still convalescent from grippe, pulled off his outer clothes and plunged in too. He at least had the honour of touching the anchor, but we agreed that we were beaten. We later negotiated unsuccessfully for a diver's suit. The statues still lie on the river bed; but we learned respect for the river. The largest ancient merchant vessels could have navigated a channel twenty-seven feet deep, and our nascent theory, that repeated inscriptional references to the pine-forests and the pitch of the hills around Minturnæ concealed proof of the existence of an important local industry in ship-building, was confirmed a few days later by the discovery of the gravestone of Q. Caelius, a "naval architect" at Minturnæ. The unsuspected port of the Liris is now receiving the recognition long denied her.



A grave of the Christian period in a dressing-room at the theatre.

In my article in *Discovery* last April I observed that the area excavated by the Austrian marshal Nugent at Minturnæ in 1819 corresponds exactly

with an area dug by ourselves during our first campaign—that of the Republican Forum. Outside of this it was obvious that the deposits had not been disturbed since the last vandal destruction of the Middle Ages. We were not as disappointed as might be supposed at having spent five months digging the Forum with no resounding sculptural discoveries; for what Nugent could not carry off he ignored, and the building foundations which he left are a hundred times more epoch-making than any quantity of museum pieces. For the first time we can study at close range the earliest Roman conception of a public square—an open area, containing a temple of the Capitoline Triad, and enclosed on three sides by a long series of small shops which presently grew up into a majestic stoa. It is this historical fact that has been so valuable to us; Minturnæ was at first a military camp and where we should have expected to find civilian comfort and convenience sidetracked or ignored we find instead city-planning for the Minturnæ to come—this in the midst of Rome's stormy career of conquest through the South Italian peninsula.

Head of a Muse which formed part of the decoration of the theatre.

Our first campaign, then, was devoted partly to excavating the Forum—and, unwittingly, to leaving the sterile traces of Nugent behind us—and partly to the Temple of Julius Cæsar and to minor trenches which, no matter how innocently they were begun, inevitably stored up fascinating obligations for the future. Two of these subsidiary trenches became prominent objectives of the campaign from which we have lately returned; the city walls of 295 B.C. and the potter's shop.

The walls make for painful excavating, for except at a few points, where foundation courses below the ancient ground level have been left, mediæval builders have looted the huge tufa blocks, and we can only follow the direction of the wall by deciphering in the virgin subsoil the channel cut by the first builders to receive the foundations. However, at the north-east corner of the theatre we had found the start of the wall, built as a continuation of an older, pre-Roman fortification, and north-west of the theatre we had located a remarkable pentagonal tower. The direction of the north wall, thus determined, was seen obliquely to cross the modern Appian Way. Digging beyond it we had the fortune to find enough blocks still *in situ* to identify two square towers. The colonial circuit was seen so to exceed our expectations that we abandoned our plan of following the north wall to the corner and returning on the west flank. Instead, we opened a trench where the Via Appia entered the Imperial city from the west, by a gate of revetted concrete which could not in any case be placed earlier than the time of Cæsar and thus could not belong to the Colony. Nevertheless, we found at once that the gate was built on the foundations of the colony wall, and of course we discovered quite without premeditation the long-sought Porta Appia of the original colony. The east, north and west walls are thus an open book and the south wall cannot remain a mystery much longer; we can already estimate the size of the city with much assurance at seventy-five acres.

Another valuable result of our latest work has been the completion of a deposit of wasters from the kiln of a local potter of about 200 B.C. In the field notes of the first campaign this excavation appeared as Trench F, a designation which has since become extricably associated with the personality of the potter himself. The tremendous scope of the ancient potter's work was really unappreciated until now; altogether a total of a hundred and ten different sizes and shapes were found—a new and startling reminder of the importance of ceramics in a period when iron and bronze provided almost imperishable utensils for every human need.

The outstanding ware manufactured by F was of no surprise. Black Campanian ware in simple shapes, without decoration or with decoration restricted to small stamps, incised lines, and a bit of white paint, is familiar in the Museums of Italy and in most European and American institutions. It offers little to distinguish it from the plain black ware which

prevailed in Greece from the fifth century down. Some of F's black-ware pottery—egg-shell cups, a "tea-pot" with a strainer in the top and a small lion's head spout, a fish-plate twenty inches across—are less familiar, and a group of toy vessels an inch in height, together with clay writing-tablets ready for the application of wax, belong rather to the Etruscan tomb-furniture of an earlier century. F further manufactured a hard, fine yellow pottery with decoration in concentric black bands; and this must have been along experimental lines of his own, for no two vases in this ware repeat the same shape, each being apparently a conception of the moment. Perhaps this ware had little success, because its fragments are not found elsewhere in the excavation.

Rare Pottery.

It is possible to study at F a class of pottery which in Italy has hitherto received only rare and disorganized attention: Campanian coarseware, for kitchen and commercial use. For the first time we are able to classify a complete series of the shapes and types and uses of common pottery in the Republican period. Early in the study it appeared that, as in the case of yellow ware, each coarse-ware vessel had a shape peculiar to itself, and that it would prove impossible to recognize categories; but later they were reduced to a simple classification. In this deposit we have also found lamps from F's wheel; the kiln breakage of these must have been small, but a dozen awaited discovery. Among them one was originally moulded into the lip of a large punch-bowl, and one gigantic lamp had four radiating nozzles.

The potter catered to the devout with clay votive offerings. Some, representing parts of the human form—feet, toes, hands, fingers—were to be dedicated at the shrines of healing; others were crude local imitations of Tanagra figurines. Again, he possessed a limited selection of clay moulds from which small decorative terra-cotta plaques were made—scenes of battle, heads of divinities and the like. Several large crude terra-cotta pine-cones suggest grave-markers.

For a more utilitarian trade he manufactured roof-tiles, drain pipes, and storage jars. Some of his pieces were signed; the presence of three different signature-stamps indicates either that his pottery was signed by workmen, or that F was not an individual but a syndicate of a co-operative group uniting on a common dump. Also scattered through the deposit were six coins which will be valuable to correct our dating, and some of the decorative stamps on the pottery itself seem to have been made from or modelled after Etruscan coins.

With these areas cleared, the theatre was in danger of remaining an unexcavated island in the middle of the city; our reluctance to begin so extensive an undertaking was overcome and we agreed to complete whatever we could in the available time. Actually we cleared the stage (the dressing-rooms in back of the stage, built on the foundations of the stoa, had been excavated during the previous campaign; they contained little but Christian tombs), the orchestra, the lower cavea, and even three of the twenty-four outer vaults which at once supported the seats of the upper cavea and provided shops for rent to the benefit of the municipality. There remains only the excavation of the remaining twenty-one outer vaults.

The theatre was built at about the end of Augustus' reign, and deserves the most careful study, for Minturnæ lies in a flat plain, providing no hillside against which to lay the rising tiers of heavy limestone seats. It was necessary here to build an artificial hill—as inevitably in the case of the more massive Roman amphitheatre—by means of upward-sloping, radiating vaults.

This delicate architecture was accomplished with a fine disregard for exact measurements; but the result is uniform and effective. The vaults which supported the lowest seats were filled with earth and completely closed, but after several centuries a local magnate restored the structure and opened a tunnel to the orchestra circle by digging out the centre vault. With this exception the theatre proper remained unchanged throughout its life.

The Stage of the Theatre.

The stage building fared otherwise and was rearranged so frequently that it is difficult to recall its original appearance. Apparently the stage was a simple raised platform, three feet above the level of the orchestra, with a slot for the curtain and an unadorned back wall. Small dressing-rooms were provided in the wings. Later a majestic scene-building was erected, with niches and columns and statues—any book on Roman architecture will show you florid illustrations. Seven statues, representing Hermes, Artemis, Hercules, Bacchus, Silenus, Marsyas and Venus, were recovered from this decoration, and of these by far the most exciting is the Hermes, for it is an adaptation of a motif hitherto represented only by the famous piece at Olympia—Hermes carrying the child Dionysus. In the current dispute over the authenticity of the Olympia Hermes the Minturno copy will play an important part.

A Decade of Bird Marking in America.

By Frederick C. Lincoln.
United States Biological Survey.

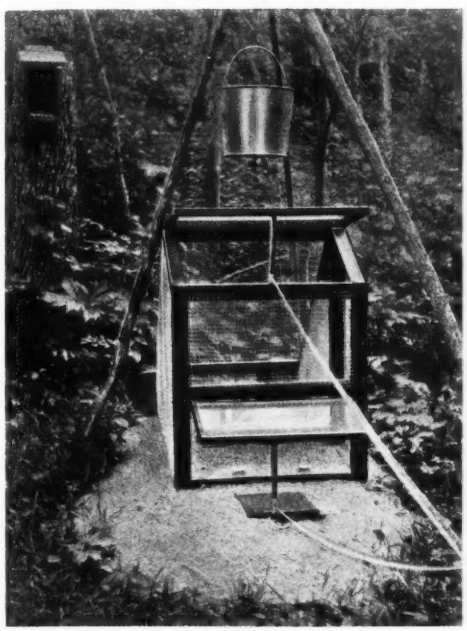
Bird marking in the British Isles has been the subject of several articles in DISCOVERY. *The following is an account of an extensive scheme in the United States. Other aspects of bird life besides migration are being studied, such as the way in which a bird develops, the transition of its plumages and its choice of mates in successive seasons.*

EVER since its inception fifty years ago, the United States Biological Survey has conducted an exhaustive study of North American birds. With the active co-operation of Canadian officials, this organization is now directing one of the greatest studies of avian life ever attempted, namely, that conducted through a continental system of co-operative volunteer bird-banding stations.

When the work was started it was natural that those species to be banded in largest numbers should be the common frequenters of our gardens, usually captured easily by the traps and methods then known. The results of the pioneer work of Dr. S. Prentiss Baldwin involved the use of traps originally developed by the Biological Survey for the control of English sparrows. His report became the first textbook and the foundation upon which the structure of future activities was laid. It was immediately obvious, however, that with our great and varied avifauna, there existed a vast field to tax the ingenuity of station operators in devising efficient means for bringing additional species within the scope of the work. The capture of the ground feeders which respond readily to cereal baits is a comparatively simple matter, but the insect feeders and particularly those whose field of action is chiefly in the tree tops presented a much more difficult problem.

The large and interesting family of wood warblers for several years defied the efforts of station operators to trap them. Many elaborate traps were worked out and pulled high in the trees by means of endless ropes and pulleys. Finally it was discovered that water in a state of motion had a potent attraction for these birds, and would frequently bring them to the ground. With this knowledge, progress was rapid until now many stations are taking them in considerable variety and number. For example, a report recently received by the Biological Survey, following the spring migration, contained the banding records for 155 warblers of nineteen species, while reports from other points show similar success.

Some of the author's early work in the field of banding had to do with the development of a satisfactory trap for ducks. The traps that had been used by market hunters were known, but generally these were found to be unsatisfactory for banding work. A short period of experiment, however, resulted in the perfection of a simple trap that gave excellent results when used for mallards, black ducks, pintails and other shoal-water species. Success here was somewhat discounted by the sceptics who openly declared that it would be a different matter when operations were begun with canvasbacks, redheads, scaups, and other deep-water species. It *was* a different matter, but already several thousands of these ducks have been banded; in fact it is now a maxim with bird banders that there is a way to trap everything if you can only solve the problem, and that you can trap any species for which you can discover an attractive bait.



Running water attracts some birds. This is a trap into which water drips from a pail above.

The smaller tree climbers, such as the brown creeper and the black and white warbler, presented another problem. As these birds ascend the trunk of a tree it had been noticed that if they met any kind of an obstruction, they generally flew to another tree. It was found, however, that if the barrier slanted upward the birds would continue to ascend, keeping a short

distance away from the obstruction. Upon the basis of this observation, a highly successful trap was devised for taking these birds. A collar of wire netting, tacked to the trunk of the tree in an ascending spiral, serves to guide the climbing bird into the trap chamber.

Migration of the Waterfowl.

Study of the distribution and migration of North American waterfowl continues to be a major project of the Biological Survey, and the number of banding records applicable to this subject is increasing rapidly. A detailed investigation of the distribution and migration of the mallard and the black duck, two of the most important species of game waterfowl, is now in progress. Several thousand return records are at hand, which make it possible not only to present in full detail the intricate movements that make up the semi-annual movements of these birds but also to portray graphically the way the flocks sweep across the country. While ornithologists and sportsmen have long understood the existence of migration routes along which birds are more or less concentrated, there has been a tendency to consider these lines of arterial traffic as narrow lanes, rather than as broad boulevards. The banding records show the general routes followed and also their approximate widths.

From a study of these data a new type of migration map has been devised to illustrate the advance and spread across the country of the ducks from any particular breeding or concentration area. Several maps of this type will show the movement of a species from different areas, and when these are superimposed on each other the resulting map should present an easily understood picture of the entire migratory flight for that species. Ducks banded in the Prairie Provinces of Canada move both south-east and south-west in the autumn. In fact, the great flocks of canvasbacks and redheads that winter on the Atlantic coast come chiefly from the interior breeding ground.

The banding work easily showed that during the migratory season there is very little interchange of waterfowl between the eastern and the western halves of the country within the United States, even with those species that have a more or less general continental distribution. On the breeding grounds in central Canada the eastern and western ducks intermingle freely, but when the time comes for migration they separate and each group adheres to its ancient routes. The proof of this lies in the fact that very few ducks banded in the United States east of the one hundredth meridian (central North Dakota, South Dakota, and Nebraska, western Kansas, and central Texas) are killed west of this line while in the United States, and vice versa.

The significance of this discovery will be more readily understood by reflecting upon the present condition of our wild waterfowl. During recent years drought, disease, over-shooting and other unfavourable factors have been disastrous to these birds, chiefly those inhabiting the western part of the country. Some species (notably the diving ducks) that visit the eastern district have also been seriously reduced, while others, such as the mallard and the pintail, that frequent the eastern plains region, the Mississippi Valley and the Atlantic coast, have not been so much affected. It is easy to conceive that these conditions might become so acute that a complete cessation of wildfowl hunting would be imperative all through the west; possibly important species of migratory game birds might be virtually extirpated over vast areas in this part of the country, and at the same time be fairly abundant east of the one hundredth meridian. The banding records indicate that should such a disaster overtake these birds, those that migrate through and winter in the east would be very slow to overflow and re-populate the devastated areas in the west even though a complete recovery of natural habitat conditions might be achieved.

There are, of course, very well-defined north-west by south-east flights of ducks, best illustrated by considering the line of migration previously mentioned and which is followed by redheads and canvasbacks in reaching the Atlantic coast from their breeding grounds in central Canada. These birds follow the general line of the Great Lakes and thence overland to Delaware and Chesapeake Bays. Such flights are not to be confused with the more nearly north and south routes of the interior.

New Knowledge of Ducks.

Sportsmen and conservation officials are keenly interested in knowing the dispersal of the ducks that concentrate at one season or another in areas which are centres of abundance. Such information is also highly practical from the viewpoint of game administration, in indicating the regions that may require special measures for their protection, such as the establishment of refuges. For example, during the time that an Act which created the Bear River Migratory Bird Refuge in Utah was pending in Congress, some opposition developed from a group of California sportsmen who contended that the number of hunters concerned with this area was too small to justify expenditure of the funds that were contemplated. The records of ducks banded in these great marshes

showed conclusively that the big flights of birds to California came through or from this section. When the data were shown on a map and made public, opposition quickly subsided.

It is common knowledge among sportsmen that the average bag of ducks is likely to contain more males than females. This, however, is not surprising since it is fairly obvious that in a mixed flock of both sexes the aim of the shooter would unconsciously be directed toward the males because of their more striking and conspicuous plumage. But it would seem that the large cage traps used to capture ducks for banding cannot be selective as regards sex. As a matter of fact, observations of the author on one species, the pintail, indicate the females to be less suspicious than males, which are frequently led into the traps by their consorts. But as early as 1922 while experimental work to develop a satisfactory duck trap was in progress a total "catch" of 388 mallards was divided into 248 males and 140 females, or a ratio of a little less than two to one. Personal experience since that time in other regions at other seasons and with other species has indicated a corresponding preponderance of males over females. Moreover, the operators of other waterfowl banding stations frequently have commented upon the relatively large numbers of males that were trapped in proportion to the females.

A trap at a bird reservation in Oregon, holding a large catch of ducks and a few Canadian geese.

Generally speaking, all birds are naturally monogamous, so theoretically it would seem logical to assume a reasonably perfect numerical equality of the sexes. This condition has been borne out by investigators who have studied the sex ratio of the domestic fowl. For example, Darwin worked out the ration as 48.64 to 51.36 in favour of the female, while more recently Professor Raymond Pearl of Johns Hopkins University, working on a basis of 22,000 chicks, obtained a ratio of 48.57 to 51.43 males to females, thus giving almost perfect confirmation to the pioneer results of Darwin. The apparent situation among our waterfowl appears, therefore, to warrant serious study.

As a contribution to the subject the author has made a statistical analysis of the banding data for certain species of ducks. The material available for study consisted of banding records from about fifty widespread trapping stations. The data represented ten of the most important species of game waterfowl and totalled 40,904. This was only a little more than half of the grand total of banded ducks, but certain lots of records were considered ineligible for inclusion in the study for various reasons. The proportion of sexes in the total number was 24,411 males to 16,493 females, or about three males for every two females.

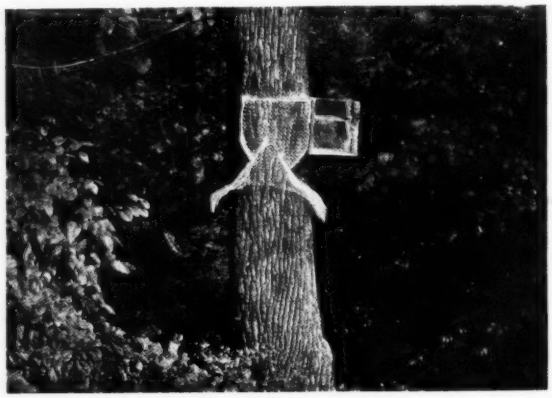
Banding problems dealing with non-game species and which engage the attention of the Washington staff of the Biological Survey relate almost entirely to distribution and migration. The general conception of bird migration is of a north and south movement. In addition, for many years we have been familiar with what is known as "vertical migration" whereby mountain-dwelling species obtain latitudinal changes in habitat by the simple expedient of moving down the mountain sides in the autumn and back again in the spring. It now appears, however, that some birds make east and west trips with the same regularity of others in their journeys between the north and the south. The evening grosbeak is an excellent example.

This large finch breeds almost entirely in the Canadian zone, and while it is a notorious wanderer, it is detected only occasionally as far south as Missouri, Kentucky and Maryland. At one banding station, operated at Sault Ste. Marie, Michigan, it is plentiful and many are banded each year. From these, several return records are available, the points of recovery extending west to Karlstad, Minn., and east to eastern Massachusetts and Connecticut. Altogether some nine or ten records indicate the remarkable "sidewise" movement of this bird. Banding records for other species indicate that east and west movements may not be as unusual as has been believed.

Extensive studies of the life history of the house wren have been intimately associated with the Baldwin Bird Research Laboratory at Gates Mills, Ohio.

Elaborate and highly technical apparatus has been developed to further the investigations and it is a fair statement that no other small bird has ever received the close attention that Dr. Baldwin and his associates have accorded this species.

Baldwin had already pointed out the interesting fact that house wrens not infrequently change mates between their first and second broods and, while of infrequent occurrence, had indicated that polygamy was not unknown. The species is unusually abundant in and around the Chagrin Valley, near which the laboratory is situated, and many wrens have returned year after year to nest in the locality. Literally hundreds of young have been banded, but strangely enough very few of these have returned to breed in their natal areas. It is well known that juvenile mortality is very heavy, ornithologists generally accepting the theory that on an average each pair of adult passerine birds will raise but two nestlings to maturity. But since the different species remain almost numerically constant, it would seem that there must be a larger percentage of survival of the young than is indicated by the few return records of yearling birds.



An "inland creeper" trap; the collar of wire netting below the trap chamber encircles the tree trunk spirally.

In an effort to answer this question, an intensive study has been made. During two seasons the entire wren population of this large area was under almost constant observation. Most of the nesting birds were repeatedly trapped and handled. While a few birds were captured that had been banded in previous seasons, in almost every instance the record showed that they were adult at the time of banding. The problem as to what becomes of the young birds is still one that challenges the efforts of the investigator.

In a study to determine the relation between the time that the adult wrens spend at their nesting activities and the time that they spend in seeking food and rest for themselves, Dr. Baldwin and his assistants invoked in the aid of thermo-electricity. A thermo-couple made of copper and constantan was installed in the nest, the thin, flexible wire passing just above the eggs with the junction of the two metals at the middle of the nest. Wires were carried from the thermo-couple to a recording potentiometer in the laboratory. Here the recording pen rested on a strip of paper marked in degrees of temperature, and this paper was rolled past the pen at a constant speed. When the female was on the nest the thermo-couple came in contact with her body, resulting in an electromotive force sufficient to move the pen in the potentiometer. In fact, so sensitive was this apparatus that a record was made on the moving paper every time the bird stood up and turned round in the nest.

During one summer a record of some 250 feet in length was obtained representing 91 days and nights. Four nests of the house wren and one of the robin received similar attention. As would be expected with these species the differentiation between the periods of attentiveness when the bird is actually on its nest, and the periods of inattentiveness, when feeding or resting, is best developed with the female, but the same relation applies also to the male. In one case a female wren was found to incubate during the day for average periods of 14.3 minutes, alternated with 6-minute intervals when she was away feeding. During the incubation period she spent every night but one in the nest. On this one occasion she left her nest at 8.50 p.m. and did not return until 1.04 the next morning.

The remarkable increase and spread of the European starling since its introduction in New York many years ago has been watched with much apprehension by students of birds. Because of the obvious potentialities of this bird for good or bad, the Biological Survey early authorized and urged its co-operators to band them at every opportunity. As a gross result many thousands are now wearing numbered bands. It has been determined that something more than 23 per cent of the wintering starlings of Washington were essentially resident birds. Determination of this fact is of much importance in planning control measures against the large winter roosts.

This article is based on an official communication to the annual report of the Smithsonian Institution, Washington.

Bridging the Irrawaddy.

By a Correspondent.

The construction of the giant Ava Bridge over the Irrawaddy river is an impressive example of modern engineering. The bridge was built entirely by a British firm in record time and nearly 11,000 *tons of steel were used.*

A PROPOSAL to bridge the Irrawaddy river was first considered as long ago as 1898, but as no borings of the river bed had been taken and no reliable information was then available, it was not considered judicious to proceed with the plan. When the scheme was reconsidered ten years later it was again postponed for financial reasons. But in 1924 plans began to take definite shape; and nine years later the bridge was completed.

The Ava bridge crosses the Irrawaddy from Armarupura to Sagaing, carrying a single railway truck and two roadways. It is three-quarters of a mile in length and consists of nine main spans and six smaller "approach spans." The various parts of the main girders were too heavy for the dock or ship cranes to handle so that a temporary assembly and riveting shop was established at Ywataung, near the bridge site. Here the heavy members were riveted and then handled by erection cranes.

Although there is a public hospital not far from the bridge site, it was considered essential to provide a small dispensary and hospital on the Sagaing bank to deal with urgent cases. For a time there was also a dispensary on the Amarapura bank. Provision was also made for those suffering from caisson disease caused by working under pressure in the piers when sinking under compressed air. As a result of these arrangements there was no outbreak of cholera or other disease although at times the labour force ran into some thousands, and in no way were the inhabitants of Sagaing disturbed by sickness due to the labour employed. It is of interest to recall the historical associations. It is said that two Ava bridges were constructed of teak at the same place by a Burmese King nearly 500 years ago. According to one writer, in 1449 A.D. Narapati, King of Ava, had a bridge constructed from his capital city over the Irrawaddy to the other side, Sagaing, for military reasons. In order to meet a Chinese invasion Narapati used all his resources to have a bridge built of teak. It took a year to complete. This bridge did not last, for King Narapati had another one constructed in its place and called the second Ava Bridge, in 1466.

Ava has been chosen as the name of the new bridge because of its prominent association with Burmese history. Ava, of which the classical name is "The City of Precious Gems," is situated at the mouth of the Myitnge river, and commanded the entrance to that river and of the Kyaukse rice granaries which, at the time, were the main food supply of the country.

It was in the tenth century that Yamankan first stockaded himself in the locality where Ava was subsequently built in 1365, by Thadomin Paya, who built the town and set up his capital there.

Ava remained the seat of government for about four centuries with a succession of thirty kings. In 1782 a new capital, Amarapura, was founded but was diverted again in favour of Ava in 1823. In 1857, however, King Mindon moved the capital to Mandalay, and, although Ava was never again reinstated as the capital, references were always made to the "Kingdom of Ava" until the final annexation of Upper Burma in 1885.

An impressive view of the new Irrawaddy Bridge.

Book Reviews.

New Light on the Most Ancient East. The Oriental Prelude to European Prehistory. By V. GORDON CHILDE. (Kegan Paul. 15*s*.).

Professor Childe does well to turn aside from his own special researches, as at Skara Brae, to survey and co-ordinate the bewildering mass of new material accumulated by his fellow-archaeologists. Discoveries multiply so rapidly that his book of 1928 on *The Most Ancient East* is now out of date and he has had to write an entirely new one. The most important features of the work are, of course, the pre-dynastic remains in Egypt, the very early and doubtless contemporaneous cultures in Mesopotamia and above all the revelation of prehistoric civilization in Sind and the Punjab that has compelled us to revise all our conceptions of early Asiatic civilization. We now have to consider three cultures, highly developed and akin in many ways, in the third millenium before Christ, in the valleys of the Nile, the Euphrates and Tigris, and the Indus. As little has been published in popular journals about the Indus diggings, at Mohenjo-Daro and Harappa, Professor Childe's account of them, brought into relation with Egypt and Sumer, is of quite exceptional interest. He gives an admirable sketch of the early history of Egypt, from the Stone Age upwards to the Old Kingdom, taking full account of the latest finds at Deir Tasi, Badrir and in the Fayum. Then he performs an equal service for Mesopotamia, with its most ancient sites at al-Ubaid and Jemdet Nasr, Ur and Kish, and brings Susa and Anau and the North Syrian Tell Halaf into the picture. Finally, he deals briefly with the Indian remains, which have yet to be fully investigated, though it is clear that these ancient Indian cities were the seats of a relatively advanced civilization which Professor Childe regards as non-Aryan and pre-Aryan. Here, perhaps, is another proof of the theory, often advanced of late, that the Aryans, whoever they were, must be regarded as destroyers rather than builders.

Professor Childe is skilled in the selection of typical details to form his pictures of these three early cultures of Asia and Northern Africa. But his general chapter concluding the work is perhaps the best of all, for it stimulates thought and shows how the archaeologist views the development of human society. The first great revolution was the change from a food-gathering to a food-producing economy. Farmers replaced the scattered hunters and fishers, and each of their little settlements had intercourse with others, as we know from the occurrence of materials from distant lands—like lapis lazuli or amber or obsidian—in their graves. The second great revolution was the development of an urban civilization based upon industry and commerce. Professor Childe evidently thinks that this began in Mesopotamia earlier than in Egypt: whether India had cities before either Egypt or Sumer remains to be proved. In any case the new movement arose out of the accumulation of a surplus of wealth, primarily of food, in the hands of a king is a priesthood. The surplus served to support merchants, craftsmen and soldiers or was expended in exchange for raw materials. Population increased and with it the tendency to emigrate if work was scarce. Thus the culture of Egypt or Sumer or the Indus was gradually diffused over neighbouring lands, by peaceful traders or craftsmen followed, no doubt, by priests and warriors. Professor Childe points out, for instance, how the Egyptian hieroglyphic reached Byblos in Syria and how the Babylonian cylinder seal was adopted in Northern Asia Minor before 2,000 B.C. It is interesting now that our economic world is greatly troubled by an apparent surplus of production, to remember that in neolithic times the surplus of wealth in the urban countries brought in a new era of human history. Professor Childe suggests to European prehistorians that Egyptian influence spread through North Africa to Spain and thence northward while Sumerian influence percolated into Eastern and Central Europe. In any case, Asia was the forerunner. From her Europe learned all the arts of civilization. We must add that this valuable and stimulating book is well illustrated and has a full apparatus of references and a good index.

A History of Exploration. From the Earliest Times to the Present Day. By BRIGADIER-GENERAL SIR PERCY SYKES. (Routledge. 25*s*.).

In this admirable summary of the exploration of the world Sir Percy reminds us that the earliest explorations were military; Alexander was as great a discoverer as conqueror. The wonderful work done by the early Chinese is only now beginning to be appreciated in this country. The earliest was Chang Kien, who started in 138 B.C. on an extraordinary series of adventures which resulted in the conquest of Ferghana, the introduction of the vine into China and the opening of the Silk Route. Among the greatest travellers of all time was Hsuang Tsang (in the seventh century A.D.), whom Sir Aurel Stein claimed as his "Chinese patron saint." Not far behind was the Arab Ibn Battuta in the fourteenth century, who visited every Moslem land in the world.

We are apt to forget that the legends of early travellers of the Mediterranean and of the Indian Ocean are buried in the *Odyssey* and the *Arabian Nights*; that the Vikings, for trade and conquest, ranged from Persia to North America; and that it was the Crusaders who taught Europe geography. Sir Percy has many unexpected items of information. We read, for instance, how Alfred, in his Anglo-Saxon translation of the *General History* of Orosius, included a description of the mouth of the Dvina, drawing his information from Othere, the Norwegian, who penetrated the White Sea in 890. The author reminds us of a fact often forgotten that the north-south caravan routes across the Sahara are of great antiquity. By them the Phoenicians traded with the middle Niger.

Among the great invading explorers Sir Percy might have included Attila and the other great Tartar chieftains, Vikings of the dry land, who with their celebrated horses ranged across two continents.

The first European to venture into the outer world, so much greater and more cultered than our own, was Marco Polo. He visited Burma (where he saw the rhinoceros which he called unicorn), and he even penetrated into Yunnan, where he observed the extraordinary custom of *couvade*.

The modern period began with Prince Henry the Navigator, grandson of our John of Gaunt, claimed by the author as the greatest man of his age. The brilliant series of exploits he inspired were commercial in inception but maintained by the fire of religious fervour. The remarkable performances of the Portuguese in Abyssinia, not mentioned by Sir Percy, were overshadowed by the dazzling brilliance of Diaz, Vasco da Gama and Magellan. There were others nearly as great, and then there were the Conquistadores. English seafarers, like the modern Vikings, preferred the cooler seas. From John Cabot, of Bristol, to H. G. Watkins there is a list of glorious names that won fame, and often death, near the Poles.

It is an inspiring book. Different as the great explorers were

in character and temperament, they were alike inspired by the loftiest motives ; all have in common a dauntless persistence. And at the end we find a strange coincidence. The Book of Exploration has been closed, the author says, by Thomas and Philby in the very corner of the globe, the south of Arabia, that is mentioned in the Book of Genesis.

Byzantine Architecture and Decoration. By L. J. Arnott Hamilton. (Batsford. 18*s*.).

The keen interest now taken in Byzantine art in England makes Dr. Arnott Hamilton's scholarly and finely illustrated volume timely and welcome. It is only a sketch of a vast subject, but it is based on long study and the personal examination of many churches in the Near East and elsewhere ; and it is so clear and attractive in style that it will stimulate the reader to follow up the subject for himself. The author takes a broad view of the theme, and includes some early and a few late buildings which are not strictly Byzantine ; but this need not be regretted. For the architecture which attained its supreme height of excellence at Constantinople was a fusion of Roman and Oriental ideas, and was enriched by many influences in the thousand years during which the Byzantine Empire was the shield of Europe against the barbarians and the promoter of civilisation through the Near and Middle East. The author begins with a concise account, that might have been fuller, of the typical plan and construction of the Byzantine church with its massive columns, its vast wall-spaces and its soaring domes, that seem to defy the laws of mechanics. He then describes the earlier churches at Constantinople, especially St. Sophia (completed in 537 to the order of Justinian), and at Salonika, and those wonderful churches at Ravenna with famous mosaics. These, of course, are familiar.

Dr. Arnott Hamilton treats what will be new ground to many readers in his chapters on the many Byzantine churches, too often ruined, in Asia Minor, Syria, Mesopotamia, Armenia, and Georgia, Palestine and Egypt, before he returns to Constantinople to describe some of the late churches like St. Theodosia or the Pantocrator. He gives a chapter to Greece and another to the Balkan countries and Russia, noting especially some of the highly interesting Serbian churches. Finally he deals with the splendid monuments at Palermo, such as the cathedral of Monreale with its glorious mosaics, with St. Mark's at Venice, and Santa Fosca at Torcello, with some churches in Apulia and Sardinia, and with that enigmatic group of churches in South Western France, such as St. Front at Perigueux or the cathedral of Cahors. Dr. Arnott Hamilton points out that St. Front was not the earliest of these domed French churches, and that their builders may have been influenced by the quasi-Byzantine churches in Cyprus, then a Christian possession, rather than by St. Mark's or its prototypes at Constantinople.

T. E. Lawrence in Arabia and After. By Liddell Hart. (Cape. 15*s*.).

Captain Liddell Hart's book is of value, not only for its account (written from a soldier's point of view) of Lawrence's historic campaign with the Arabs against the Turks, but for the author's able and penetrating analysis of his subject's intriguing character. Captain Liddell Hart has nothing but praise for Lawrence's strategy in the desert ; his policy was to harass the Turks by continual attacks on railways and outposts while carefully avoiding pitched battle, and to deflect the enemy from the main front in Palestine by encouraging their hopes of retaining Medina.

Lawrence's subsequent career has earned him the title of a " mystery man." It is not surprising that one who had led so eventful a life found a research fellowship at Oxford uncongenial, and his early relinquishment of the post of adviser to the Colonial Office is still less to be wondered at. It was no surprise when Colonel Lawrence became Aircraftsman Shaw. He is still in the service of the Royal Air Force, but is due to retire next year. Captain Liddell Hart explains this change of name and rank by likening Colonel Lawrence to the mediæval monk seeking the peace and seclusion of a monastery. It may be supposed that Lawrence could have achieved his wish without accepting the lowest rank in one of the services ; but it is feasible to assume that if he could not be in complete command he would prefer to hold the humblest position.

It will be interesting to follow the fortunes of this intriguing person when his present service ends ; meanwhile Captain Liddell Hart's book is an able attempt to estimate his character.

The Butterflies of the Malay Peninsula. By A. S. Corbet and H. M. Pedlebury. (Kyle, Palmer and Co., Kuala Lumpur. $4.50.).

Those favoured lovers of nature who live in the Malay Peninsula now have a good handbook, which will not only enable them to identify their captures among the 800 species known to occur there, but to learn the practical methods of making and preserving collections in the tropics. There are also chapters giving a clear introduction to the subjects of Mimicry and Mendelism. It is curious to read that the spread of tar macadam and of surface drainage has already had a marked effect in reducing the fauna even of so teeming an area. English readers, by the way, may feel a little aggrieved that the pride of our Fens, the Swallow Tail, is alluded to as " a rather small butterfly."

It seems a pity to create trivial names where they have not existed before. Scientific names have never frightened gardeners, and we decline to believe that any serious student has really been discouraged from the study of entomology by their appearance. Still, if we must have popular names, the taste of General Evans with his " Painted Jezebels " is better than that of our predecessors who perpetrated such monstrosities as the " Setaceous Hebrew Character."

The advice for coping with tropical conditions is useful. Pins of nickel and stainless steel are now available, but these are required only by residents. It is to be hoped that, with the stimulus provided by the growing literature on the subject, local enterprise will before long provide the apparatus for collecting, so that use may be made of the field experience of men who know ; for the nets sold by dealers in this country have not improved in design for the past fifty years. A dry season will usually shrink wood so drastically that the screws fall out. The material used for butterfly nets as a rule offers much scope for improvement. Sweep-nets sold by English dealers are bad both in design and material, and almost useless in practice. The book is full of useful and stimulating information, such as the fact that the resemblance between the alpine (and oldest) fauna of Malay Peninsula and that of Sumatra is close enough to suggest that the subsidence which separated them is comparatively recent.

Many of the species mentioned are increasingly uncommon. *P.brookiana*, one of the most splendid, appears to be dying, for the sex ratio is one female in a thousand. The extinction of this wonderful creature, which measures over six inches in expanse of

wing and is restricted to a limited area, would indeed be a misfortune. The wealth of the fauna is shown by the presence of no less than 180 species of *Hesperidae*; it is surprising to note that *Cosmolyce baeticus*, L., which is an occasional visitor to the south coast of England, ranges right across the Old World from the Mediterranean, through the Oriental region to the Pacific Islands, and has become established in Hawaii. The greatest surprise of all is the existence of a carnivorous butterfly, for the larva of *Gerydus* eats Aphides.

Mass Spectra and Isotopes. By F. W. Aston, F.R.S. (Arnold, 15*s*.).

Towards the end of last century the attitude of scientists to the atomic theory began to undergo a change. What had until then been regarded as a mere working hypothesis now became a statement of definite fact. As Dr. Aston points out in this able and detailed study, this change of attitude is now complete, and in any well-equipped laboratory to-day not only can individual atoms be detected, but the movement of the swiftest of them can be tracked and made visible even to the untrained eye. The reason for this advance was chiefly the discovery of radio-activity, which has provided us with atomic projectiles possessing enough energy to produce visible and measurable effects individually; it is also due to the steady improvement in technical methods. "Subject to such unprecedented scrutiny," the author writes, "it was to be expected that the fundamental physical theories which underlie the applied science of chemistry and form a solid mathematical foundation for its formulæ, might show hitherto unexpected flaws." Such expectations, as he recalls, began to be realised when, among the radio-active elements, Boltwood failed to separate ionium from thorium and, among the inactive elements, Sir J. J. Thomson a few years later observed the anomalous behaviour of neon when subjected to positive ray analysis. Still more careful scrutiny of these flaws revealed them not as fortuitous and disconnected, but as a definite and ultimately intelligible pattern.

It is with the interpretation of this pattern, so revealed, that Dr. Aston is concerned, and in the first part of his book he looks back over a century to the beginning of the theories forming the background against which it was first observed. Dr. Aston traces the progress in the discovery of non-radio-active elements from 1919, when definite proof of the existence of the isotopes of neon was published, to the present time, when out of all the elements known to exist in reasonable quantities, only eighteen remain without analysis. Of these eleven are rare earth elements.

The Yeoman's England. By Sir William Beach Thomas. (MacLehose. 8*s*. 6*d*.).

The title of this book suggests the country of the small freeholder, the sturdy class which "next below the gentry," as the dictionary has it, played so great a part in making England what it is. It suggests the England which Mr. Baldwin loves to praise, and we were hoping for something on a national scale to correspond with what Mr. Adrian Bell has done so admirably for the yeomen of Suffolk. It is therefore disappointing to find that Sir William Beach Thomas has given us instead a countryman's calendar, dealing with nature month by month, on the basis of articles contributed to the *Observer*. Delightful as these are, it is necessary to make this criticism as the author stresses in his preface that, while a "great many people have written memorably about little bits of England . . . no one has written well of England as a whole." Yet it is in the first category rather than the second that his book must be placed.

Having said this, nothing but praise remains for the descriptions which Sir William Beach Thomas gives us in his survey, which ranges from a day on the Fens in frost to a walk in the gardens of Oxford, with much about new-mown hay, harvest, insects, apples, and a thousand other country things. Naturally the birds claim a great many pages, and the fifteen photographs that illustrate this book are alone worth its modest price. "The Yeoman's England" should be very popular as a textbook for nature study, though written for the wider public which loves the countryside for itself in all its moods and seasons.

Exploring the Upper Atmosphere. By D. M. Fisk. (Faber & Faber. 3*s*. 6*d*.).

In his article on another page, Sir Percy Sykes mentions the study of the upper atmosphere as a significant new phase of exploration. Miss Fisk's little book is topical. The subject is a new one, and it is not an easy task to present the problems involved in a simple and readable way; Miss Fisk has succeeded in writing a fascinating introduction to the subject which should have a wide appeal. In an introduction, Dr. Leopold Brose reviews the earlier investigations which eventually led to Professor Piccard's pioneer ascent. He points out that much is yet to be discovered and new problems will unceasingly present themselves, disclosing the infinite richness and variety of our nearer surroundings as well as of those that will for ever remain beyond our reach. In this book, the layman will find the present state of our knowledge of the stratosphere ably surveyed, and for the scientist it forms a useful and concise summary.

The wide publicity which the popular Press has naturally given to a novel form of scientific enquiry may have lent an undeserved appearance of sensationalism to this important science. That is inevitable; but Miss Fisk's book is sober and responsible, and as the first of its kind it is to be welcomed.

The Peregrine's Saga. By Henry Williamson. Illustrated by C. F. Tunnicliffe. (Putnam. 7*s*. 6*d*.).

Many people write about the countryside, but few have the happy style of Mr. Williamson. Those who remember the author's *Lone Swallows* will know what to expect in *The Peregrine's Saga*. Mr. Williamson is almost unique in resisting the temptation to be sentimental about rustic things. No one has a keener or more sensitive eye, and few are able to express their observations so attractively on paper. This is a collection of stories of which the titles indicate their character; one is called "The Air Gypsies," another "The Weed's Tale," and another "The Mouse." The concluding story, from which the book takes its title is perhaps the best. But throughout, Mr. Williamson holds the interest of the reader. There could be no more appropriate illustrations than Mr. Tunnicliffe's woodcuts. He has captured the mood of the author.

Toads and Toad Life. By Jean Rostand. Translated from the French by Joan Fletcher. (Methuen. 7*s*. 6*d*.).

In many ways the Batrachians are remarkable among vertebrates, and we are indebted to M. Rostand for a detailed account of the most highly developed and most intelligent member of the class. It is extremely individualistic in taste, concerning itself with the affairs of the species only for three weeks of the year. Much has been learned from the toad in the laboratory, and this book gives a good account of experiments.